केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

CHANGLANG DISTRICT, ARUNACHAL PRADESH

उत्तर पूर्वी क्षेत्र, गुवाहाटी

North Eastern Region, Guwahati

MINISTRY OF JAL SHAKTI

जल शक्ति मंत्रालय

Department of Water Resources, River Development and Ganga Rejuvenation

जल संसाधन, नदी विकास और गंगा संरक्षण विभाग

GOVERNMENT OF INDIA

भारतसरकार

REPORT ON AQUIFER MAPPING AND MANAGEMENT PLAN OF **CHANGLANG DISTRICT, ASSAM**

ANNUAL ACTION PLAN, 2022-23

By

Shri Rajat Gupta,

Assistant Hydrogeologist

Central Ground Water Board
State Unit Office
Naharlagun (Itanagar)
Arunachal Pradesh
March 2023

Contents

LIST OF TABLES

LIST OF FIGURES

CHAPTER-1.0

INTRODUCTION

1. Introduction

Central Ground Water Board, North Eastern Region has carried out Aquifer mapping and management plan in Changlang district, Arunachal Pradesh as per the Annual Action Plan 2022-23 and the area covered is 530 sq.km. Under National Aquifer Mapping and Management (NAQUIM) program, combination of geologic, hydrologic and hydrochemical information is applied to characterize the quantity, quality and sustainability of ground water aquifers. Systematic aquifer mapping will improve our understanding of the geologic framework of aquifers, their hydrogeologic characteristics, quality and also quantifying the available ground water resources potential and proposing plans appropriate to the scale of demand and the institutional arrangements for management. Aquifer mapping at the appropriate scale can help to prepare, implement and monitor the efficacy of various management interventions aimed at long-term sustainability of our precious ground water resources, which, in turn, will help achieve drinking water security, improved irrigation facilities and sustainability in water resources development.

Objectives

The objectives of this project are to understand the aquifer systems up to 200 m depth, to define the aquifer geometry, type of aquifers, ground water regime behaviours, hydraulic characteristics and to establish groundwater quantity, quality, and sustainability, and to estimate the dynamic and static resources accurately through a multidisciplinary scientific approach on 1:50,000 scale and finally formulate a complete, sustainable and effective management plan for ground water development.

Scope of the study

The activities of this Aquifer Mapping and management plan can be envisaged as follows:

1.2.1 Data Compilation & Data Gap Analysis: One of the important aspect of aquifer mapping program was the synthesis of the large volume of data already collected during specific studies carried out by Central Ground Water Board and various Government organizations with a new data set generated that broadly describe an aquifer system. The data were assembled, analyzed, examined, synthesized and interpreted from available sources. These sources were predominantly non computerized data, which was converted into computer based GIS data sets. On the basis of available data, data gaps were identified.

1.2.2 Data Generation: There was also a strong need for generating additional data to fill the data gaps to achieve the task of aquifer mapping. This was achieved by multiple activities such as exploratory drilling, hydro-geochemical analysis, remote sensing, besides detailed hydrogeological surveys to delineate aquifer system; to bring out the efficacy of various geophysical techniques and a protocol for use of geophysical techniques for aquifer mapping in different hydrogeological environments.

1.2.3 Aquifer Map Preparation: On the basis of integration of data generated from various studies of hydrogeology, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared bringing out characterization of Aquifers, which can be termed as Aquifer maps providing spatial variation (lateral & vertical) in reference to aquifer extremities, quality, water level, potential and vulnerability (quality & quantity).

1.2.4 Aquifer Management Plan Formulation: Aquifer Maps and ground water regime scenario are being utilized to identify a suitable strategy for sustainable development of the aquifer in the area.

Approach and Methodology

Aquifer mapping has been carried out by adopting a multi-disciplinary approach:

(i) Geophysical Surveys through Vertical Electrical Sounding (VES)

(ii) Exploratory drilling and construction of bore wells tapping various groups of aquifers

(iii) Ground Water Regime monitoring by establishing monitoring wells tapping different aquifers at different depths for long term monitoring of water level and quality

(iv) Pumping test of bore wells, soil infiltration test for determination of ground water recharge scope, intensity and potentials and also to determine the characteristics and performances of existing aquifers at various depths.

(v) Collection of various relevant technical data from the field in aquifer mapping area and also from the concerned State Govt. Agencies and other Institutes dealing with ground water and incorporating these data along with CGWB data for final output.

(vi) Preparations of a micro level mapping of existing aquifers, their potentials depth wise and sideways in 2D and 3D forms viewed from different angles by various GIS Layers.

(vii) Formulating a complete sustainable aquifer management plan for ground water development

Area Details

The Changlang district of Arunachal Pradesh lies between the Latitudes 26°40'N and 27°40'N, and Longitudes 95°11'E and 97°11'E. The study area is located between the latitude 27° 8' 40.9848" N and 27° 36' 27.8856" N and 95° 38' 1.7268" and 96° 17' 12.2712" E. It is bounded by Tinsukia District of Arunachal Pradesh and Lohit District of Arunachal Pradesh in the north, by Tirap District in the west and by Myanmar in the south-east. The district is having a total area of 4662 sq. km and mappable area of 530 sq.km. District area falls partly or fully in the quadrants of Survey of India Toposheets bearing nos. 83M/11, 83M/12, 83M/14, 83M/15, 83M/16, 83N/9, 83N/1392A/2, 92A/3, 92A/4, 92A/6, 92A/7, 92A/10, 92A/11, 92A/14, 92A/15, 92A/16 and 92E/3, 92E/4. The total population of the district is 148226, of which 76948 males and 71278 females. The literacy rate of the district is 59.80 %. (Census 2011)

Administrative set up of the study area

The administrative setup is based on single line administration which aims to keep close co-operation amongst various developmental departments with the district administration and thus, to work together for the speedy development of the area. The district has four Sub-Divisions and a total of 12 circles as shown in Table 1.1 below. The Deputy Commissioner being the overall in-charge of the district administration maintains law and order with the help of administrative officers and police forces. Moreover, the villagers have their own customary administrative systems in the form of traditional village councils consisting of the Gaon Buras and members.

Table: 1.1. Sub-Division, Blocks and Circles in Changlang District

Name of Sub Division	Name of Blocks	Name of Circles
Changlang	Changlang CD Block, Changlang	1. Changlang
		2. Namtok
		3. Yatdam
		4. Kantang
	Khimiyang CD Block, Khimiyang	Khimiyang
Miao	1. Khagam CD Block, Miao	1. Miao
		2. Kharsang
		3.Vijaynagar
		4.Namphai
Jairampur	1. Nampong CD Block-Nampong	1. Nampong
		2. Rima Putok
		3.Jairampur
	2.Manmao CD Block, Manmao	1. Manmao
		2. Renuk
		3. Lyngok - Longtoi
Bordumsa	1. Bordumsa CD Block Bordumsa.	1. Bordumsa
	2. Diyun CD Block Diyun	1. Diyun

Source: District Irrigation Plan, 2017

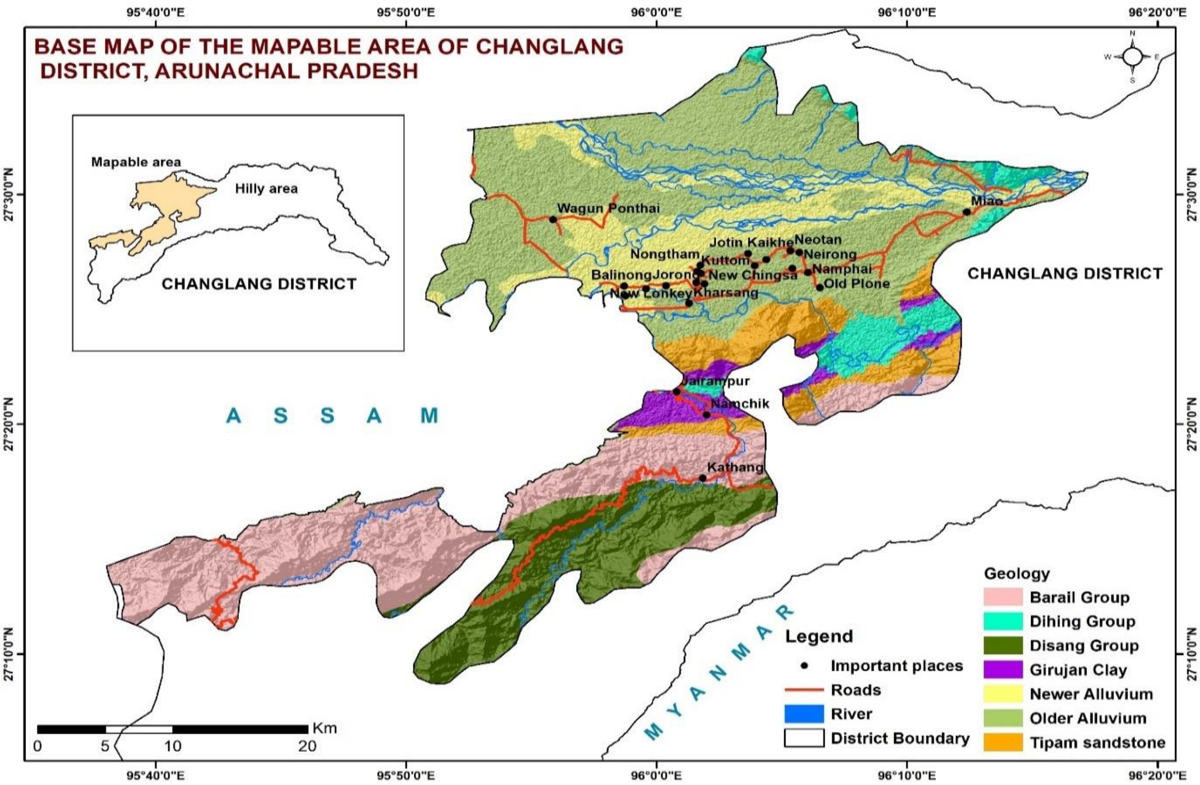


Fig. 1.1: Base Map of Study area

Rainfall Distribution

The average annual rainfall recorded from 2017 to 2021 in Changlang district is 1911mm. Rainfall during January to April contributes nearly 17.79% to the total rainfall whereas the rainy season which commences from May and continues up to September contributes 76%. October to

December rainfall makes up the rest. December receives least rainfall and maximum rainfall occurs during July. The average monthly rainfall from 2017 to 2021 are tabulated in Table 1.2.

Table: 1.2. Rainfall variations of Changlang District from 2017-2021

Year	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	1.66	43.13	166.81	286.31	246.62	257.86	427.57	393.02	327.02	205.28	20.5	1.15
2018	28.95	66.91	166.65	139.6	247.78	299.64	242.15	94.49	197.36	42.46	18.6	46.61
2019	24.75	69.15	114.57	117.85	675.04	281.44	500.91	167.39	280.65	70.75	6.5	2.76
2020	49.9	17.43	32.17	182.08	260.7	466.91	273.43	285.36	288.79	132.27	49.1	0
2021	7.85	6.16	68.84	113.18	282.6	152.69	211.78	275	42.45	53.31	10.29	17.29
Average	22.62	40.56	109.81	167.8	342.55	291.708	331.168	243.052	227.25	100.81	20.998	13.56

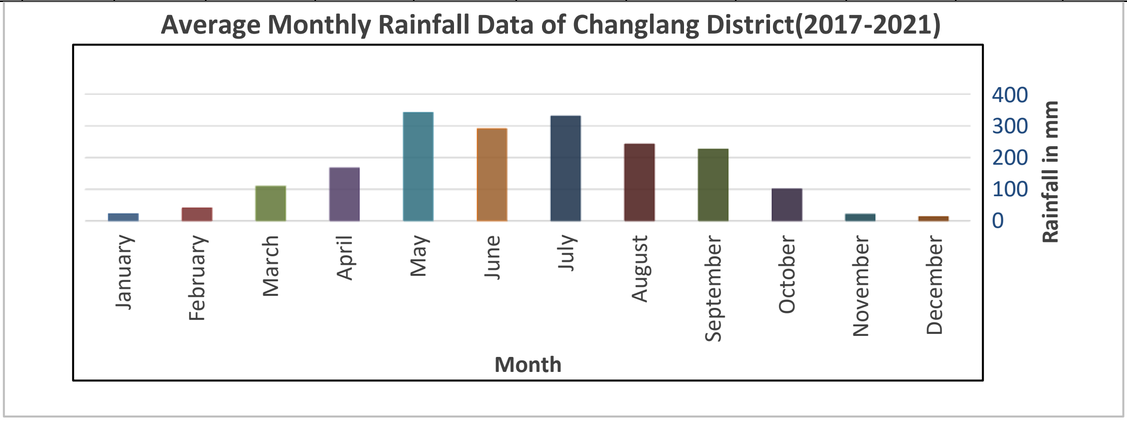


Fig. 1.2: Average monthly rainfall of Changlang district(2017-2021)

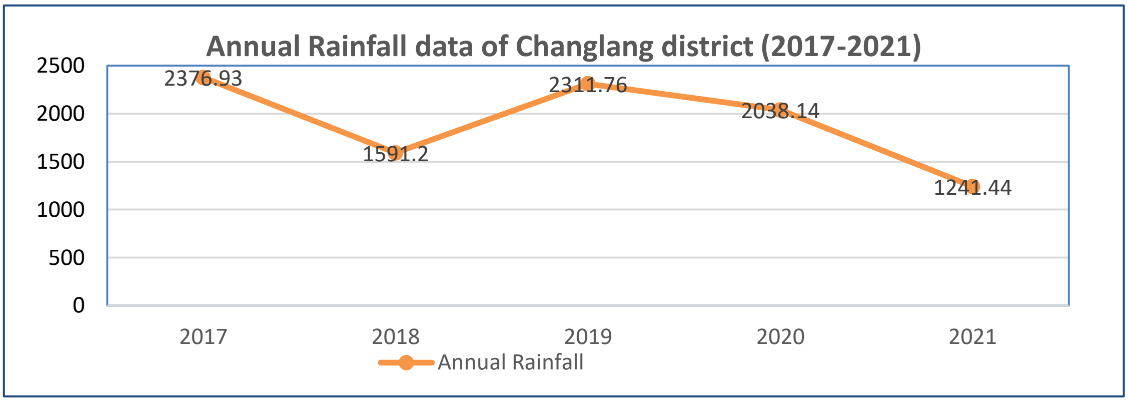


Fig. 1.3: Annual rainfall variations of Changlang district (2017-2021)

Rainfall and Climate

The rainy season starts from April and continues up to September. There is a sharp variation in the quantity of rainfall at different places depending upon the geographical setting and topography of the area.The district enjoys a sub – tropical to temperate climate. The climatic conditions vary from place to place due to mountainous nature of terrain. The altitudes also vary from 200 meters to 4500 meters over the peaks from sea level. Places like Miao, Kharsang, Jairampur, Bordumsa and Diyun, which are located in lower elevations and in the valleys, experience hot and humid climate in summer during June-August. In the hill areas, the climate is moderate and pleasant. December to February months is cold. January is the coldest month when the average maximum and minimum temperature is about 22° C and 13°C respectively. August is the hottest month during which temperature may occasionally exceed 30.20 °C. The average maximum temperature is about 26.96 °C and minimum 18.63 °C.

Physiographic set up

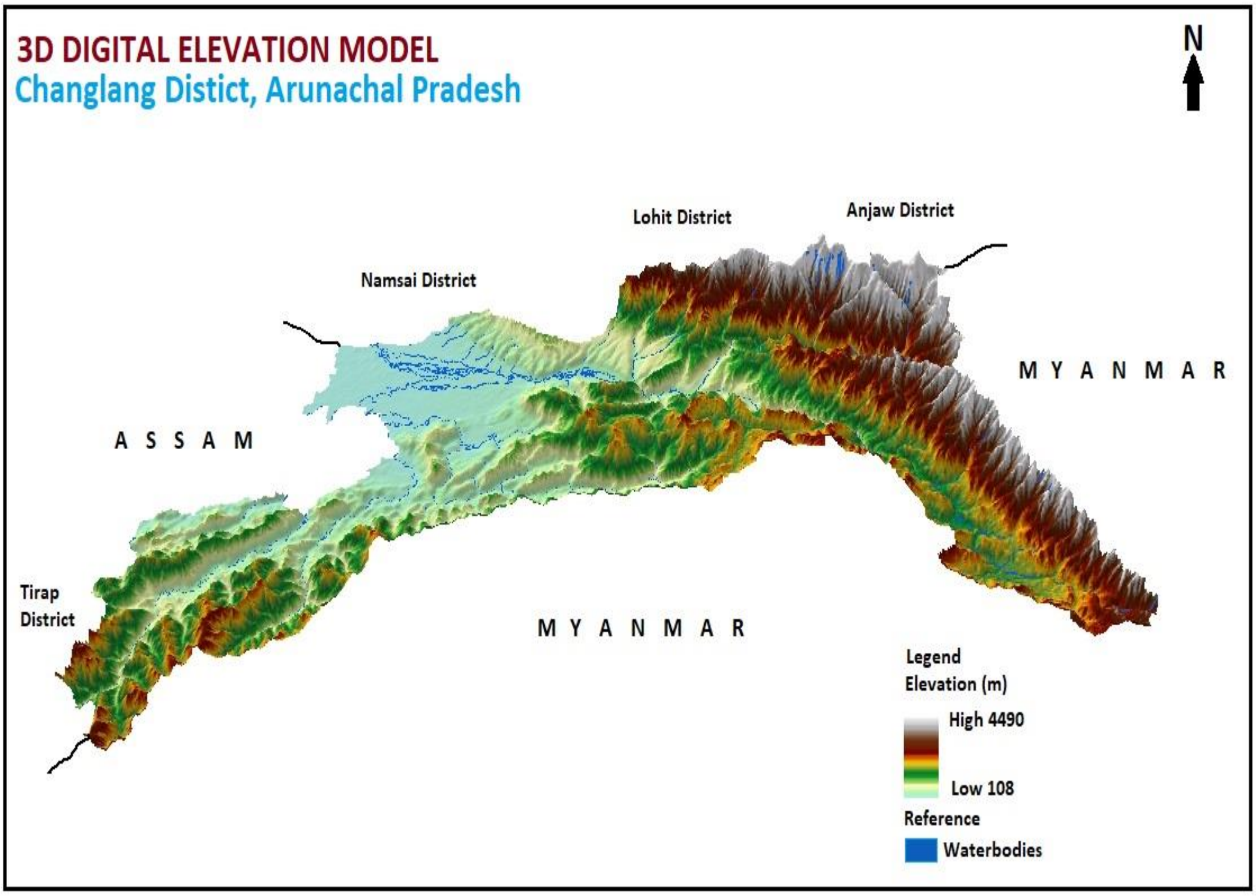
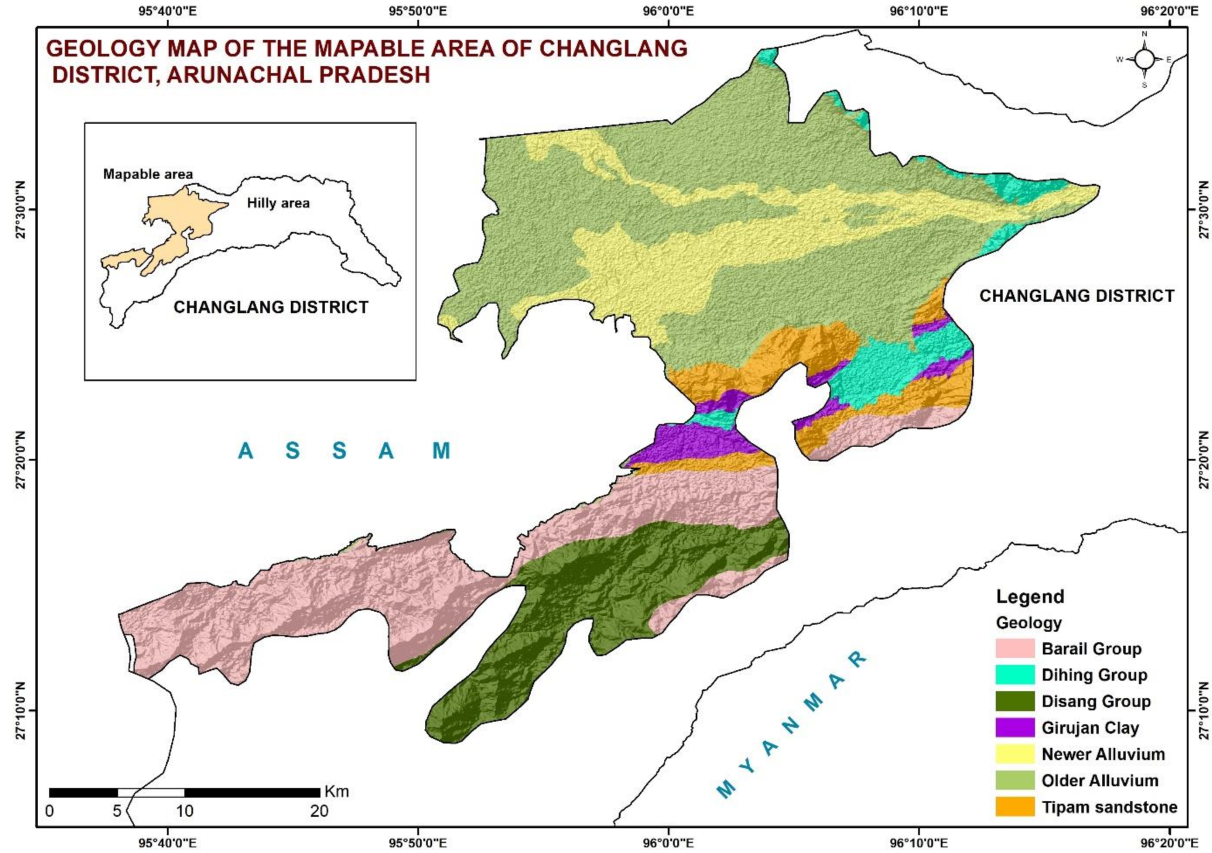


Fig: 1.4. Digital Elevation model (DEM) of the changlang district

Physiographically, the area is highly uneven with very thick vegetation and is characterised by (1) flat to low hills in the northern parts (2) high ridges and peaks in the central part and (3) narrow and steep gorges in the southern part. The minimum and maximum elevations in the area are 108 m. and 4490 m above mean sea level respectively. Majority of the ridges trend NE-SW while few trend N-S. The general trend of the ridges is parallel to the regional tectonic lineament.

Geology geology of the district varies from newer alluvium to metamorphics of Proterozoic and the district is structurally charaterised by anticlines, synclines, ripple marks, faults and multiple phases of folding. The area comprises of various rock types belonging to Alluvium, Disang, Barail, Tipam and Dihing group which is interrupted with the presence of unconfirmity.

The Barail group consists mainly of Sandstone, shale, Siltstone, clay and coal seams. The Dihing Group comprises of Pebbles, Conglomerate, Sandstone and Tipam group consists of sandstone, shale and clay. The other group like Disang consist of shale, quartzitic sandstone and siltsone.



The

Fig: 1.5. Geological Map of Changlang District, Arunachal Pradesh

Geomorphology:

Geomorphologically the district has been divided into two units, i.e denudational structural hills and alluvial plain. Major parts of the district are occupied by denudational structural hills consisting of Tertiary formations. The hill ranges form high hills and narrow but deep intermontane valleys. Topographic elevation increases from northeast to west and southwest. The elevation is about 300 mamsl in the northwestern alluvial plains followed by low to moderate linear ridge of elevation ranging from 300 to 600mamsl. This is followed by moderate hill ranging in elevation from 600 to 1350mamsl. The high hills are ranging in elevation from 1350 to 4500mamsl. Daphabum is the highest peak with an elevation of 4500 mamsl. The plains of Changlang district occupy about 530 sq.km. area in and around Miao and Bordumsa town. This plain has a regional gradient towards south – west.

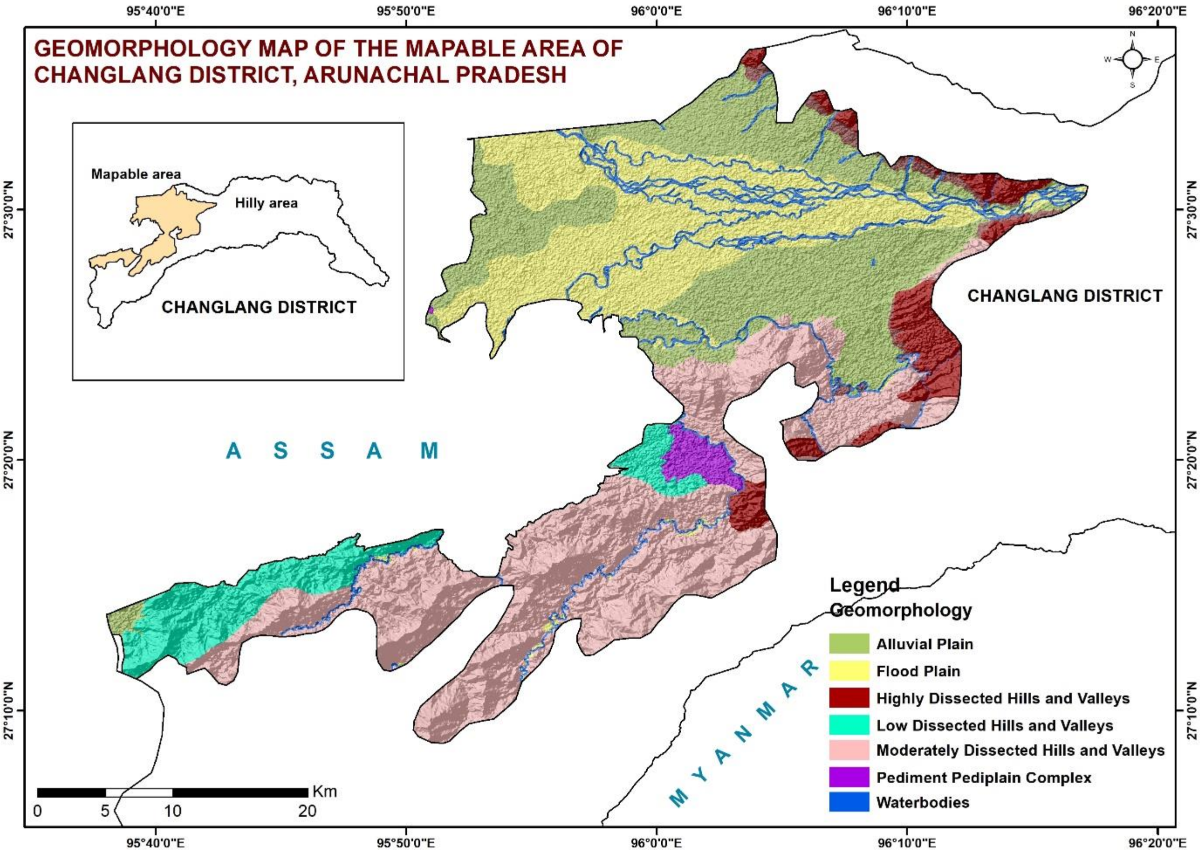


Fig: 1.6. Geomorphological Map of Changlang District, Arunachal Pradesh.

Land use Pattern

Major parts of the district are hilly with rugged terrain and have a thick forest canopy. Plain areas are found only in Miao, Diyun, Bordumsa and Kharsang circles and a few narrow strips of flat land in some parts of Changlang, Jairampur, Vijoynagar, Nampong and Namtok circles and compared to the total area of the district, plain area is meagre.

Table: 1.3. Land Utilisation in Changlang District

Land put to different uses	Area in hectares
Total Area Reported	45904
Forest Land	4153
Land not available for cultivation	2022
Permanent pastures and other grazing land	2543
Land under Misc. Tree crops	
Cultivable Wasteland	2543
Current Fallow	1217
Other Fallow	8852
Net Sown area	27117
Total or Gross Cropped area	27472
Area cultivated more than once	355
Cropping Intensity[GCA/NSA]	1.01

Source- NABARD PLP-2016-2017 Changlang

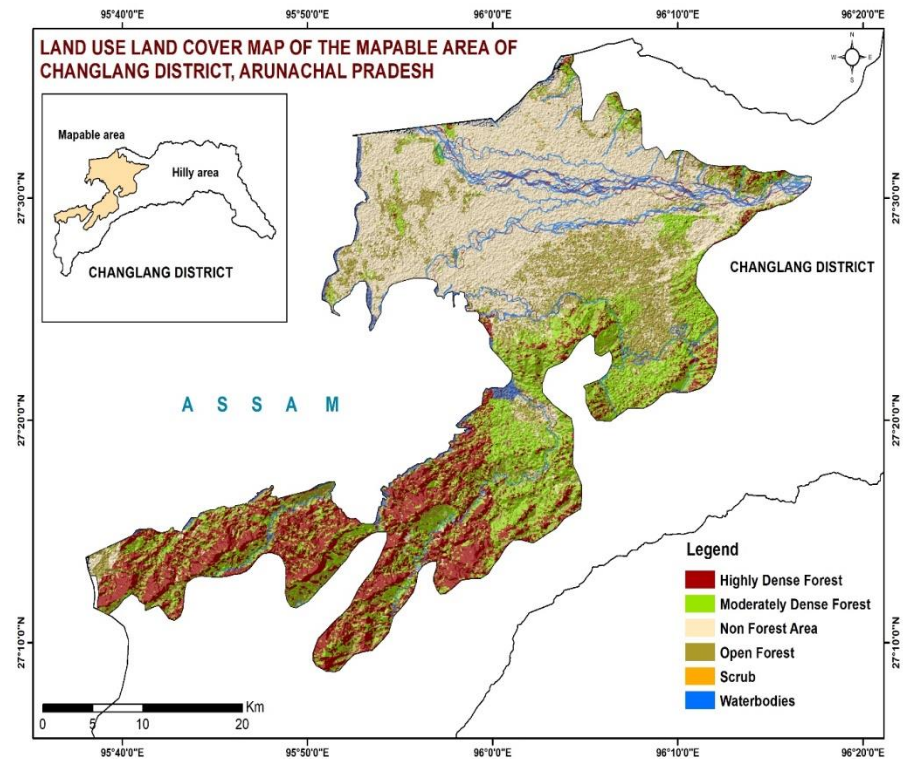


Fig: 1.7. Land Use Land Cover Map of Changlang District, Arunachal Pradesh.

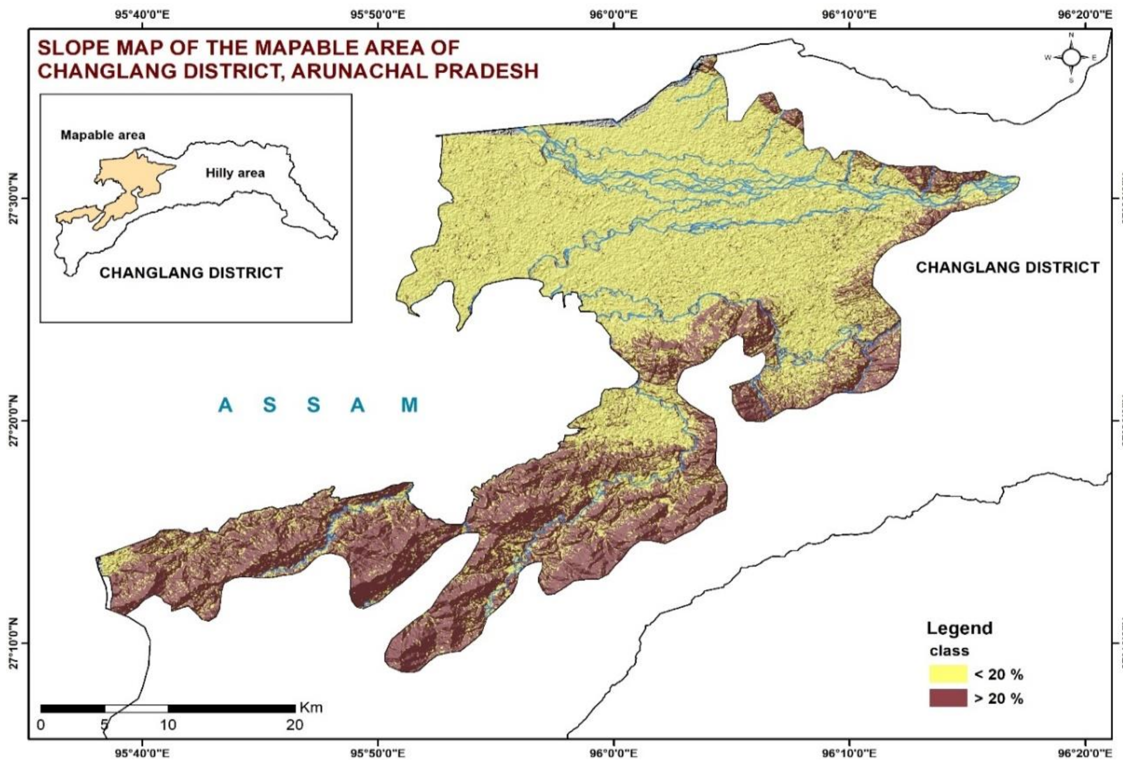


Fig: 1.8. Slope Map of Changlang District, Arunachal Pradesh.

1.12 Slope

The area is dominantly under more than 20% slope and hydrogeologically does not act as a recharge zone whereas the upper NE area of the district is less than 20% slope and can be considered for development of Groundwater. The area covered under less than 20% slope of the mappable area of 530 sq. km is 328.6 sq. km and more than 20% is 201.4 sq.km

1.13 Soil

The soils of the district are derived mainly from Tertiary groups of rocks. The district has pre-humid hyperthermic soil type. The parent rocks are sandstone, shale, siltstone and mudstone. Soils of the district are mainly acidic with very high organic carbon and poor in phosphate and potash contents. Soils are fertile and are classified into alluvial and residual soils. Alluvial soils are again classified into recent alluvial or entisol and older alluvium or oxisol and ultisol. Recent alluvial soils occur in the valleys and form continuous sheet along the banks of streams and rivers. The soil comprises of clay, silt and sand and occurs in Bordumsa – Miao plain. Older alluvium is found in the foothill areas and intermontane valleys. They comprises of sand and gravel admixture with clay and silt. (Source: District Irrigation Plan, 2017)

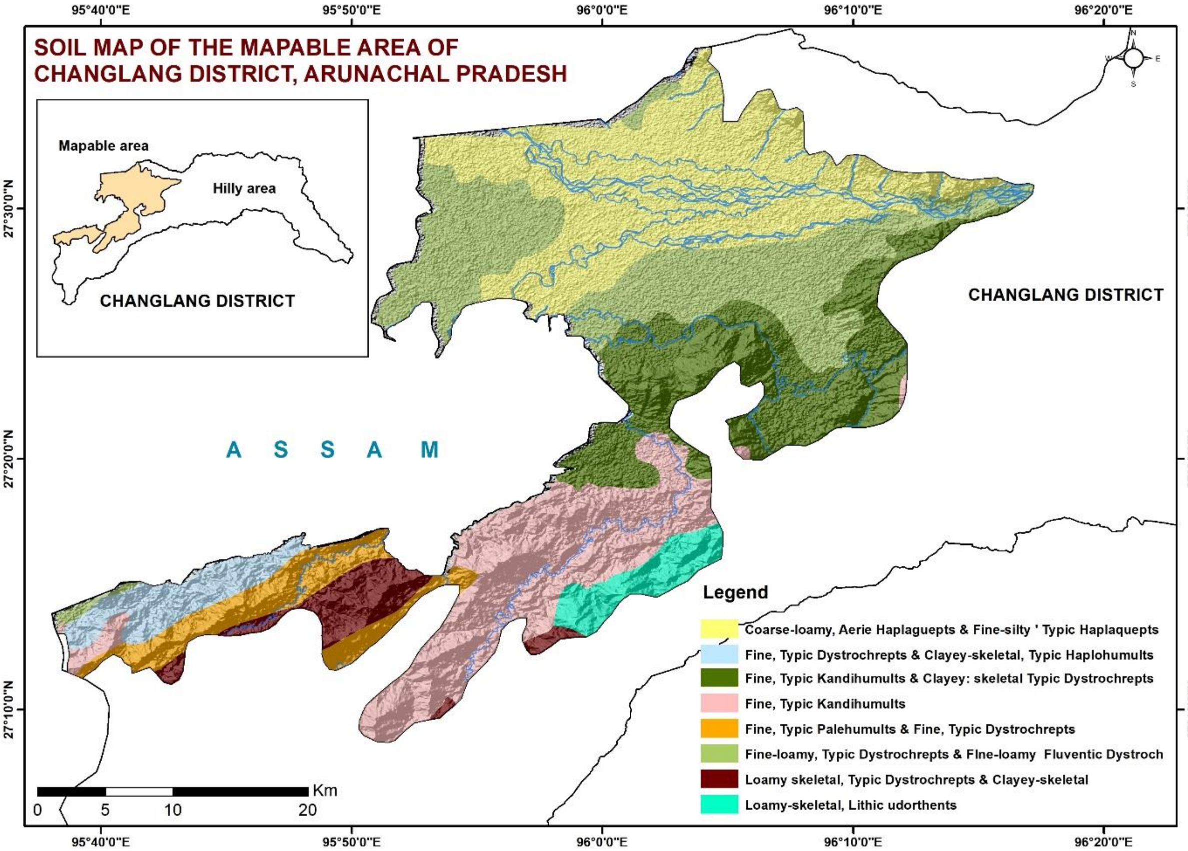


Fig: 1.9. Soil Map of Changlang District, Arunachal Pradesh

Hydrology and Drainage

The district can be divided into three distinct hydrogeological units, viz., consolidated, semi-consolidated and unconsolidated (Map II) formations based on geology, hydrogeological character and topography. The Disang and Barail groups of rocks constitute the consolidated formations and this unit occupies nearly 80% of the district.

The semi-consolidated formation of the district is represented by the Dihing and Namsang groups and is exposed in the Manabum anticline. Out of the three anticlines in the Manbum area, the south Manabum is a large asymmetrical anticline. The Dihing Group is composed of pebble bed and a transition bed, which is composed of alternation of pebble layer and medium to coarse sand.

Namsang Formation is composed of massive medium to coarse loosely bedded sandstone with thin clay layers, wood fossils, coal and thin conglomeratic layers. This unit occupies nearly 5% of the district.

Unconsolidated formation occupies nearly 530 sq. km of the district and comprises about 15% of the total district area. The unconsolidated formation is comprised by recent alluvium consisting of gravel, sand, silt, clay, etc. Alluvium is exposed in the northeastern part of the district around Miao – Bordumsa area.

The groundwater potential of the consolidated formation is very limited. This unit acts as a runoff zone. However, a small part of rainwater percolates through the joints and fractures of these compact rock which in turn ooze out in the form of springs.

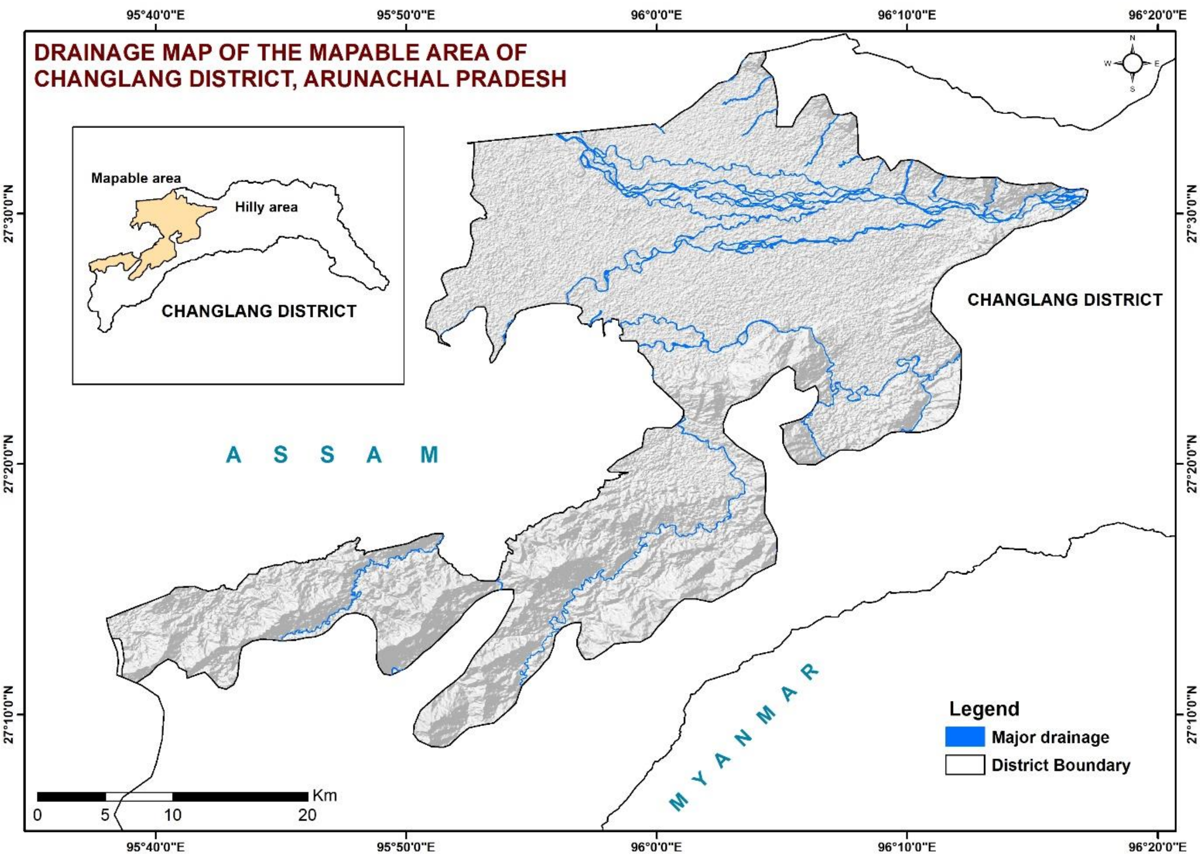


Fig: 1.10. Drainage Map of Changlang District, Arunachal Pradesh

All the rivers in the district flow to the Brahmaputra and the area comes under Brahmaputra basin. The major Rivers are Noa-Dehing, Namchik and Tirap. Other Rivers are Namphuk, Dapha, Namphai, Tissu, Tarit, Tara, Tikeng, and Tiging. Most of the rivers after winding through the hills and valleys come down to the plains and join Buri-Dihing River. The Noa-Dihing River, which originates from Patkai Range flows east to west through the entire northeastern and northern stretch of the District. The Tirap rises from a high peak between Laju and Wakka and flows Southwest to Northeast passing through the Changlang town ultimately meet Buri-Dihing near Lekhapani in Assam. The drainage density is moderate to high indicating the compactness of the formations. The overall drainage pattern is mainly dendritic to sub dendritic with local developments of parallel and radial pattern.

Agriculture and Plantation

The economy of Changlang district is basically agrarian in nature with about 80% of the population dependent on agriculture. Rice is the major crop. Other important crops include oil seeds, pulses, jute, vegetables etc. The agro climatic conditions of the district are conducive for various agricultural activities. Agriculture in the district is characterized by over dependence on rainfall, predominance of seasonal crops and traditional methods of cultivation.

The main crops grown by the inhabitants are rice and millet. Other crops are maize, root crops like yam, Arum, Tapioca, sweet potato and local vegetables varieties such as chilly, ginger, garlic, potato, pumpkin, gourd, brinjal etc. Besides, tobacco, betel vine, oilseeds, spices etc. are also grown. In Manmao and Khimiyong areas opium is also cultivated.

Fruits like orange, pineapple, jackfruit, banana, pears, papaya, walnut, plum, peach, litchi, guava, mango, lemon, citronella, black pepper, coconut, large cardamom and others are grown in different parts of the district.

There is a congenial atmosphere for raising of cash crops like, Coffee, Tea, Big Cardamom and rubber in Changlang District. Tea plantation is taken up at almost all parts of the district. As Bordumsa is suitable for rubber and Tea plantations, newly Tea and Rubber plantations are rapidly coming up there and tea plantations in other parts of Changlang district, places like Nampong, Changlang and Namtok.

(Source: District Irrigation Plan, 2017)

CHAPTER- 2.0

DATA COLLECTION AND GENERATION

Hydrogeological data

The entire study area is covered by regular monitoring of 04 nos. of GWMS and another 10 wells have been established. All the water level data were collected and the wells are monitored periodically.

Exploration data

CGWB has constructed 07 no's of exploratory wells in this area earlier and during current annual action plan (2022-2023) one (01) no. of piezometer well has been constructed.

Meteorological Data

Meteorological data is collected from accessed free data of WRIS IMD.

Population and agriculture data

Population and groundwater dependency were collected from Census 2011. All the data pertaining to agriculture were collected from District Irrigation Plan of Changlang District for 2017 prepared by NABCONS.

Data Generation:

Water level data: 10 nos. of key wells have been established to fill up the data gap. All these wells are under periodic monitoring after establishment.

Table 2.1: Key wells location details: -

Name of Village/Site	Latitude	Longitude	Establishment date	RL (ma msl)	Total depth of Pz/Dw (mbgl)	Type (DW/Pz/Spring)	Aquifer group	Measurement point (magl)	Source/ Agency
Ongman	27.4162	95.99171	Key Well	169	5.90	DW	Alluvium	0.88	Private
Gelenja dumsa link rd	27.5262	95.89283	Key Well	156		H. pump		0.30	Private
Namchik chk Gate	27.4145	95.97191	NHNS	167.53	6.76	DW		1.20	Private
Jairampur	27.4146	95.97199	NHNS	167	7.0	DW		1.10	Private
New lisan	27.4269	96.0418	NHNS	183.3	4.39	DW		0.67	Private
Namphai	27.4460	96.10863	NHNS	207.23	4.65	DW		0.70	Private
Bordumsa WRD div.	27.5187	95.87974	Key Well	156	88.4	Pz		0.90	CGWB
Namphong	27.3370	96.0462	Key Well	192	11	DW		0.73	Private
Namphainong	27.4440	96.08438	Key Well	193	5.10	DW		0.88	Private
Diyun	27.5401	96.10315	Key Well	205	7.62	DW		0.63	Private
Innao khamti	27.5507	96.01598	Key Well	172	3.40	DW		0.35	Private
Mudoi chk gate	27.5592	95.96268	Key Well	162	5.0	DW		0.55	Private
Bijoypur-I	27.4991	96.00774	Key Well	174	3.85	H. P		0.31	Private
Bijoypur-I	27.4984	96.0111	Key Well	174	3.80	DW		0.73	Private

N. B.: (1)Private well means wells constructed by individual household, Tea Garden, Petrol Pump, Temple, Masjid, etc.; HP means Hand Pump & DW means dug well

Table 2.2: Water level measurement of key wells

Location	Month & depth-to-water level				
	Jan-22	Apr-22	Aug-22	Nov-22	Mar-23
Ongman				3.33	
Gelenja dumsa link rd		2.3		2.24	
Namchik chk Gate	4.61	3.56		3.47	4.55
Jairampur	5.18	2.18	2.56	4.82	2.18
New lisan	5.92	4.73	1.90	4.63	5.18
Namphai	4.32	2.3	2.60	1.95	4.95
Bordumsa WRD div.				1.5	4.3
Namphong				4.85	
Namphainong				1.92	
Diyun		3.26		3.14	
Innao khamti		0.27		1.49	
Mudoi chk gate		0.92		2.17	
Bijoypur-I				2.46	
Bijoypur-I				1.94	

Table 2.3: Salient features of the test sites

Site	Location	Land use	Soil type	Latitude	Longitude
Ongman	In the campus of Ongman middle govt. school, Miao	Barren Land	Silty loam	27° 24' 58.49" N	95° 59' 30.15" E
Rajanagar III	In the campus of General ground, Rajanagar III	Barren Land	Sandy loam	27° 28' 53.64" N	95° 55' 23.08" E
Diyun	In the campus of Circuit House, Diyun	Barren Land	Sandy loam	27° 32' 38.85" N	96° 5' 33.06" E

Table 2.4: Summary of Infiltration Test

Site	Land use	Soil type	Infiltration rate (mm/hr)	Duration of test (min)	Total Quantum of water added in m	IF = (4)/ (6) *100)
Ongman	Barren Land	Silty loam	32.5	132	0.17	4.33
Rajanagar III	Barren Land	Sandy loam	310	130	0.165	53.93
Diyun	Barren Land	Sandy loam	75.3	153	0.17	10.40

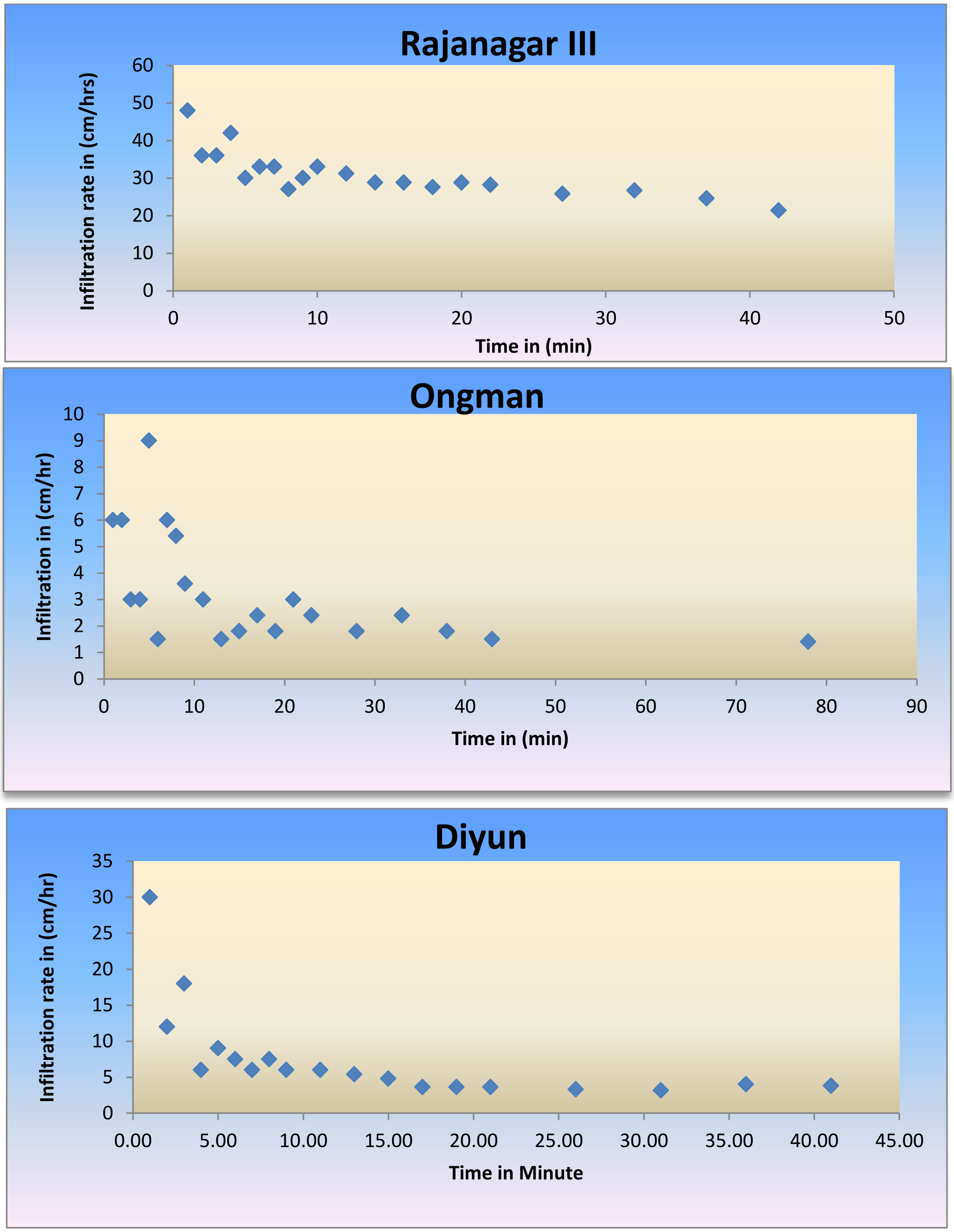


Fig: 2.1. Time Vs Soil infiltration rate plot.

Geophysical Survey: In surface geophysical methods, physical properties of subsurface formations and contained fluids are measured by instruments located on the surface. All the operations are carried out on the surface only. Out of the many techniques, electrical resistivity methods are most widely used in groundwater studies. The main objectives of the geophysical surveys are to provide the information about the thickness of weathered and fractured zones, depth to bed rock, delineation of solution cavities in Karst formations, structural and stratigraphic conditions controlling ground water occurrences etc. During AAP

2022-23, there was 05 no's VES conducted in the area. CGWB old record were collected and examined. The location details of these VES survey is shown in Table 2.5

Table 2.5 Location details of VES data: -

Sl. No .	Block	Location	Lat	Long	Elevation	Depth of interpretation
1	Changlang	ITI Balinong	27.4490847	95.969401	166	32
2	Changlang	Dangoritol	27.4485360	95.9701494	166	38
3	Changlang	Balinong Vill.	27.4398564	95.9702851	165	75
4	Changlang	Namchik	27.4154805	95.9757069	166	21
5	Changlang	Ongman	27.4169329	95.9918319	170	40
6	Changlang	ITI balinong	27.4353871	95.9584653	163	40

Water Quality: To understand the chemical quality of groundwater in the study area and its suitability for domestic, drinking and agricultural utilization, and existing quality data of CGWB (Figure.13) were collected. Water samples were collected from monitoring wells for detailed, iron, heavy metals and arsenic.

Exploratory Drilling: During AAP 2022-23, 01 no. of piezometer well drilled by CGWB in study area. 07 nos of Exploratory wells drilled by CGWB before NAQUIM are examined for preparation of section/3D disposition of aquifer. A list of wells constructed in the area was prepared incorporating location, well designs, etc. Distribution of wells in the district is shown in Fig. 2.1.

Table 2.6: Details of Exploratory wells in Changlang District, Arunachal Pradesh

S. N	**Location**	**Block**	**Lat**	**Long**	**RL**	**Depth (m)**	**Discharge m3/hr**
1	Taipong	Nampong	27°19’44’’	95°50’52’’	152	70	NA
2	Nongtham	Khagam Miao	27°25’40’’	96°0’0’’	178	62	8.8
3	Goju	Bordumsa	27°28’15’’	95°53’16’	156	61	17.1
4	New Khimyang	Khimyang	27°27’57’’	96°6’30’’	219	57.5	9.45
5	Lonkam Panthai	Bordumsa	27°26’44’’	95°56’42’’	162	57	NA
6	Sikao	Miao	27°25’40’’	96°0’0’’	313	134	1.5
7	T.R.Camp	Miao	27°26’45’’	96°07’02’’	206	55	NA
8	WRD div bordumsa	Bordumsa	27°31'7.1"	95°52'47.05"	156	88.4	8.8

Fig: 2.2.(A) Measuring Ground Water level and (B) In-situ measurement chemical parameter by water quality testing kit (C) Collection of water sample and (D) Conducting Soil Infiltration test

CHAPTER-3.0

DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.0 Data Interpretation

The subsurface geology of Changlang District is interpreted based on exploration data of Central Ground Water Board (CGWB). The drilling depth of CGWB's exploratory well ranges from 55 to 134 mbgl.

Table 3.1: Distribution of EW based on drilled depth.

Depth	< 50m	50-100m	100-150 m
No of wells	0	7	1
% of wells	0	87.5	12.5

From the examination of available litholog, it is observed that down to a maximum explored depth of 134m. The sequence is dominated by, sand, clay, sandy gravel and clay mixed with sand, boulder and sandstone. The available data indicate major aquifer of the district is Alluvium of quaternary age, the mappable area which is upper central part of the district is occupied by Tipam sandstone, Barail and Dihing group of tertiary age.

Aquifer Disposition:

Following sections are constructed to show the 2D disposition of aquifers in the district.

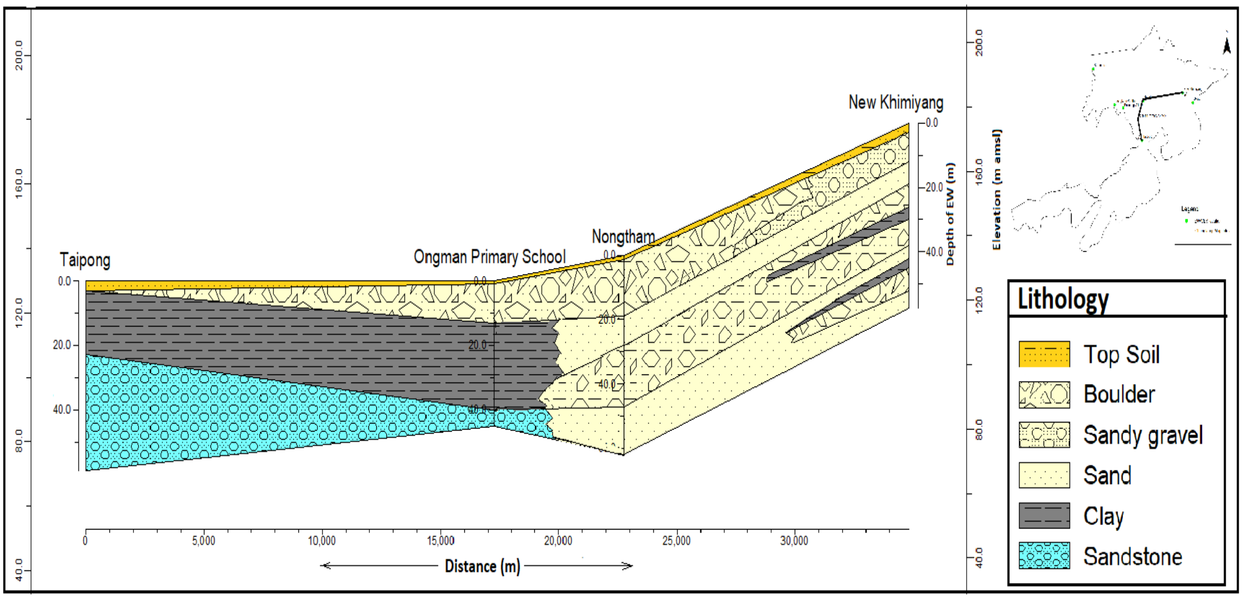


Fig: 3.1. Cross sections A-A' between Taipong-New Khimyang.

(i) Cross section A-A' along Taipong-New Khimyang: Section prepared in NE-SW direction of the study area which is perpendicular to the Noadihing river showing two minor clay beds in the eastern side and one thick clay bed in the center of the study area.

These clay layers are absent in Nongtham EW. Along Nongtham-New Khimyang stretch, the aquifer material is dominated by boulder, sandy gravel and sand upto 60 m thickness. However, along Ongman VES -Taipong EW clay and sandstone is dominated.

(ii) Cross section B-B'along Bordumsa-Ongman: Section prepared in NW-SE directionof the study area, perpendicular to the hills of the southern side of the district. The thickness of the granular zone is more in the Bordumsa EW than in the Lonkam panthai and Ongman. In Bordumsa EW mono aquifer zone appears to exist upto a depth of 88m whereas in lonkam panthai it is composed of Boulder and Tertiary sandstone, which gradually thins out in Ongman VES. The ongman area is dominantly of Boulder and clay which occurs upto a depth of 40m. The aquifer material along this section is mainly dominated by sand, and boulder.

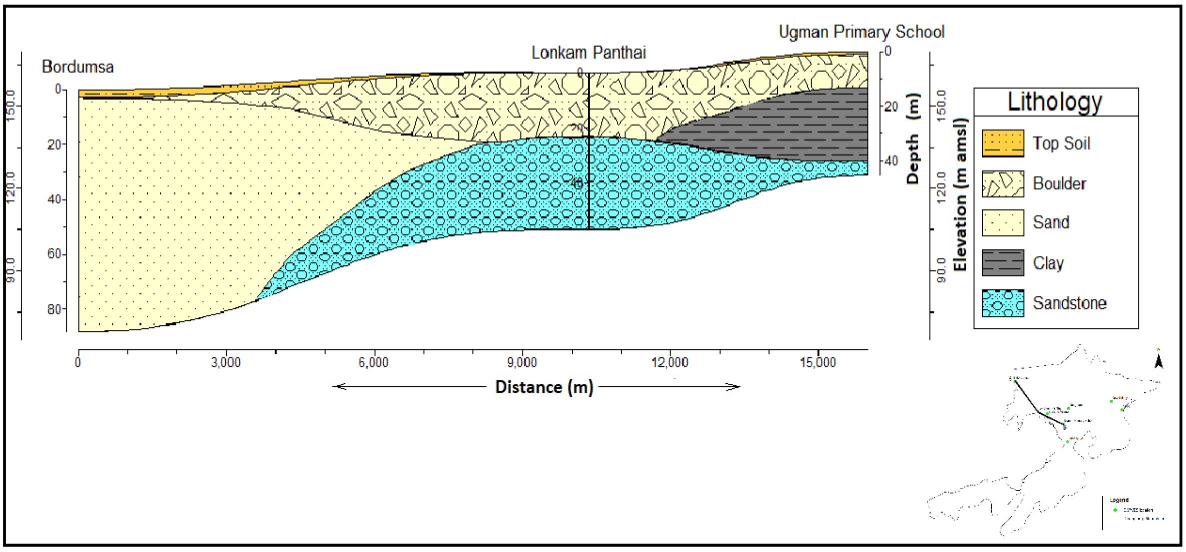


Fig 3.2. Cross sections B-B' along Bordumsa-Ongman.

3D disposition of aquifer:

The fence diagram and 3D aquifer model of the district indicate that the sub-surface formation in the alluvial plain is dominated by sand, sandy gravel, boulder, sandstone and clay. Various clay layers encountered south to Brahmaputra River of district and thickness of this layer increasing toward center part of the study area. Granular zone thickness increasing toward north and west of the study area. The maximum thickness of aquifer is attained near border area od assam, where huge sand layer is prominent near bordumsa acting as a mono aquifer. Towards the south of the bordumsa, the granular zone decreases and aquifer layers encountered clay and sandstone of tertiary age. Towards north of the district, the granular zones appear with some clay layers in between of the sand and boulder layer.

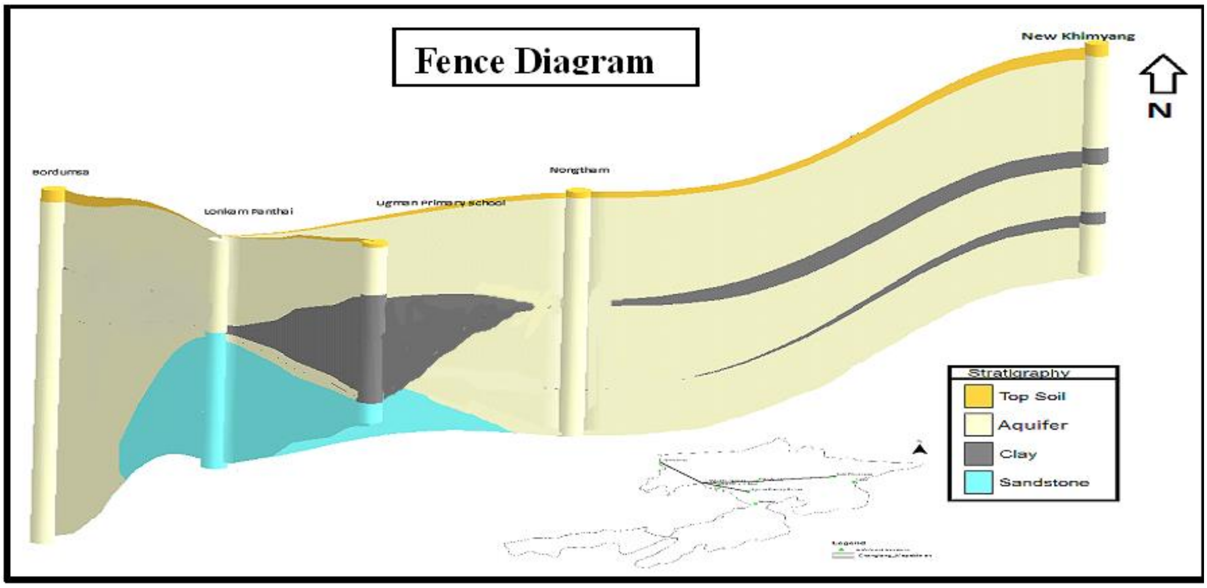


Fig 3.3. Fence diagram of showing aquifer disposition.

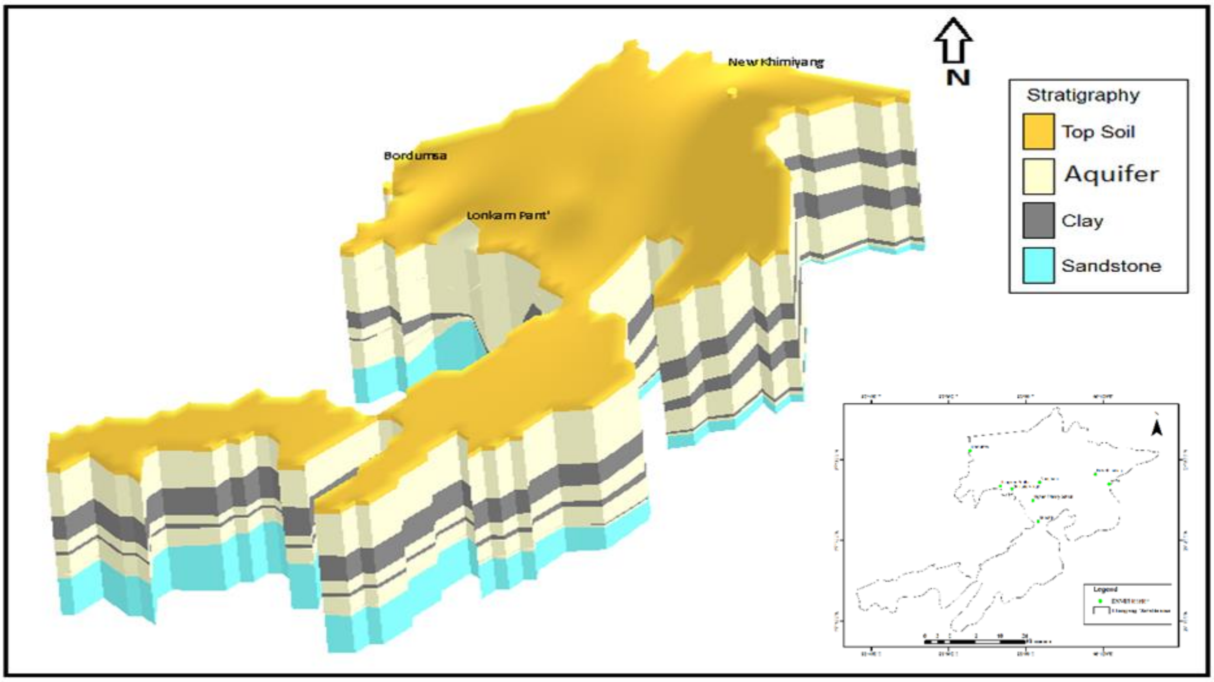


Fig: 3.4. 3D aquifer disposition of Changlang study area.

Aquifer Characteristics:

Major aquifer of district is older alluvium (AL03). The aquifer of the district broadly can be divided into two groups. Shallow aquifer depth limit is 50m and below which deeper aquifer exists. The cumulative thicknesses of both shallow and deeper aquifers are given in Table 1.

Shallow Aquifer zone: In shallow aquifer granular zone thickness varies from 0m to 50 m, and granular zone thickness increasing toward north of district. It is observed that lowest thickness of this zone is found towards centre part of the area in Taipong and ongman. Towards west of the study area, bordumsa where it attains a maximum thickness. The predominance of clay formation in the centre part of the study area in the depth of 50 m poses problem in storage of ground water in shallow aquifer.

Table 3.2: Granular zones encountered in exploratory wells in Changlang District, Arunachal Pradesh

Village/Location	Drilled Depth (m)	Granular Zones/ Potential Zones Encountered	Cumulative thickness of granular zones (m)	
			GL to 50 m	50 to 150 m and above
Taipong	70	15-17, 23-25, 30-32, 37-70	19	20
Nongtham	62	6-18, 19-28, 29.5-40, 42.5-62	39	12
Goju	61	8 – 16, 20 – 22, 24 - 34, 52 - 58	20	6
New Khimyang	57.5	3 – 26, 32 – 42, 45 – 57.5	37	7.5
Lonkam Panthai	57	9-23, 38-42, 44-50	24	NA
Sikao	134	4 - 68, 70 -74, 102 - 112	46	32
T.R.Camp	55	5 - 54	45	4
WRD div Bordumsa	88.4	7-57, 67-85	43	35

Deeper Aquifer Zone: The cumulative thickness of deeper aquifer beyond 100 m could not be ascertained in all exploratory well, only 1 exploratory well have completed 100 mbgl or above depth, however based on the available information it can be confirmed that 4 to 34m cumulative thickness of granular zones are available. The thickness of granular zone decreasing toward center part of the study area. Groundwater within this depth range occurs under semi-confined to confined condition. Transmissivity value ranges from 467 to 3111 m2 /day. Discharge varies from 5.4 m3/hrs to 61.56 m3/hrs, for drawdown of 1.45m to 3.21m.

Table 3.3: Aquifer properties of deeper aquifer zones.

Depth Range	SWL (mbgl)	Discharge (m^3/hr)	Drawdown (m)	T (m^2/day)	Permeability (m/day)
50-134 m	2.05 to 19.90	5.4-61.56	1.45 – 3.21	467 - 3111	15.56 -259.25

Ground water level of shallow aquifer zone: To study ground water regime, depth to water level from 14 monitoring stations (GWMS 04, Key well 10) are measured seasonally. In pre-monsoon, the depth-to-water level varies from 0.27 to 4.95 mbgl and in post monsoon depth-to-water level varies from 1.49 to 4.85 mbgl. In pre- monsoon highest water level recorded in Namphai, Miao Khagam block and lowest at Innao Khamti of Diyun Block. In post- monsoon highest water level recorded in Namphong of Nampong block and lowest at Innao Khamti of Diyun. (Fig. 21 and 22).

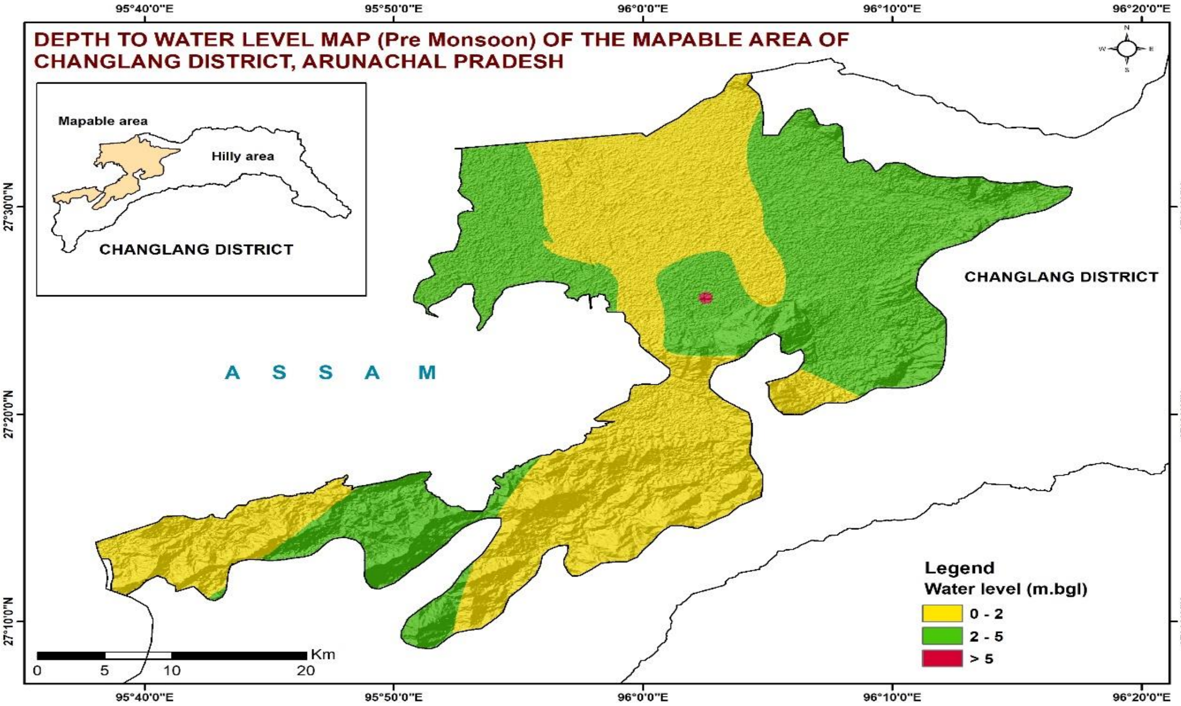


Fig 3.5: Premonsoon groundwater level map shallow aquifer of the study area.

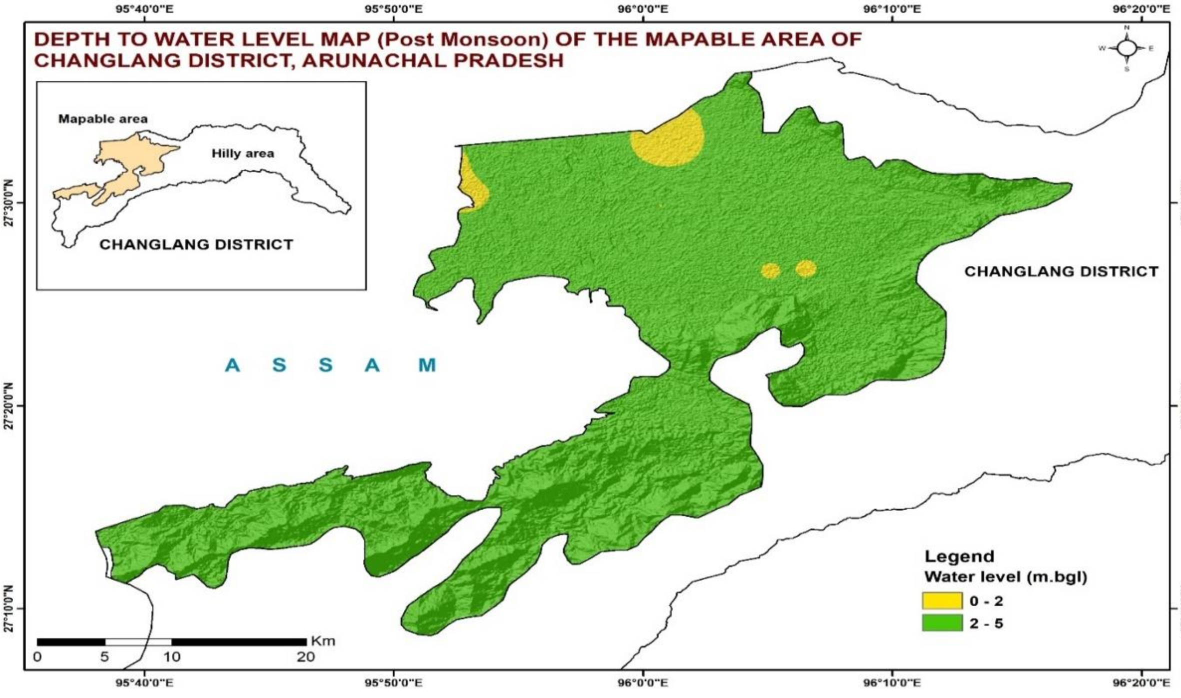


Fig 3.6**:** Post-monsoon groundwater level map shallow aquifer of the study area.

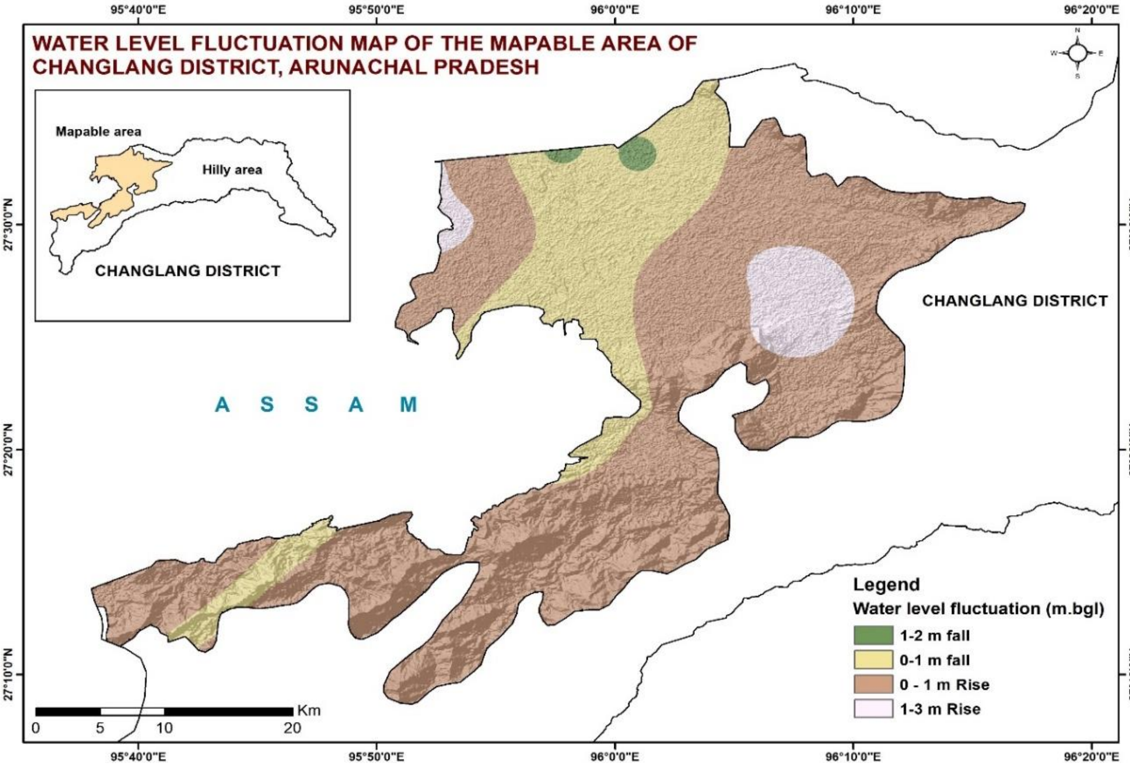


Fig 3.7: Water Level fluctuation map of study area.

Seasonal fluctuation of water level ranges from -2.64 m to 3.0m. Highest fluctuation observed in Namphai of Khagam-miao block and Bordumsa of the district. Most of area showing water level fluctuation less than 1.0 m. (Fig. 3.7).

Ground Water Movement

The water table contour has been prepared based on water level of ground water monitoring stations which is shown in Fig.3.8 The ground water flow direction toward Brahmaputra River and parallel to Noadihang river. The highest water table is 210 m and lowest water table 160 m above the mean sea level.

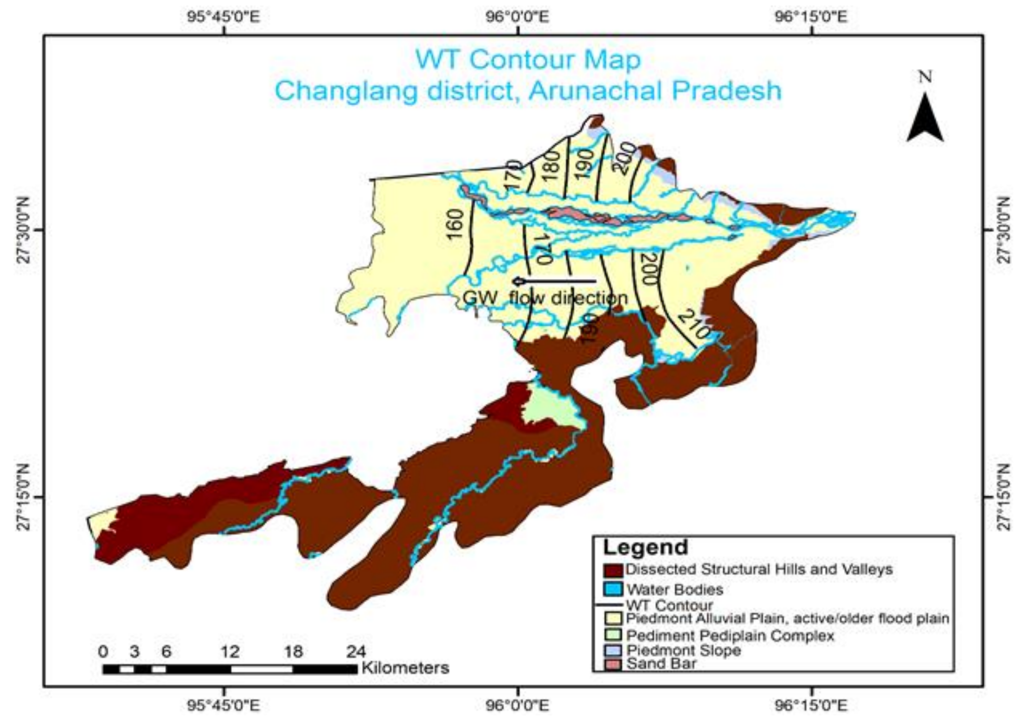


Fig 3.8: Water Table Contour map of study area

Water level trend analysis

For analysis of long-term behavior of ground water level, data from Ground Water Monitoring Stations (GWMS) are utilized. Historical depth-to-water level data (in mbgl) are plotted as individual hydrographs and are given in Figure 3.9 and Table 3.4 showing overall trend of water levels in GWMS wells of Changlang district, Arunachal Pradesh.

Table 3.4: Trend of Water levels in GWMS Wells

SN	Locality/Name	No. of years	Water Level Trend	
			Post-monsoon	Pre-monsoon
1	Namchik	9	Rise	Rise
2	Jairampur	9	Rise	No significant change
3	Namphai	9	No significant change	Fall
4	New lisan kharsang	9	Rise	Rise

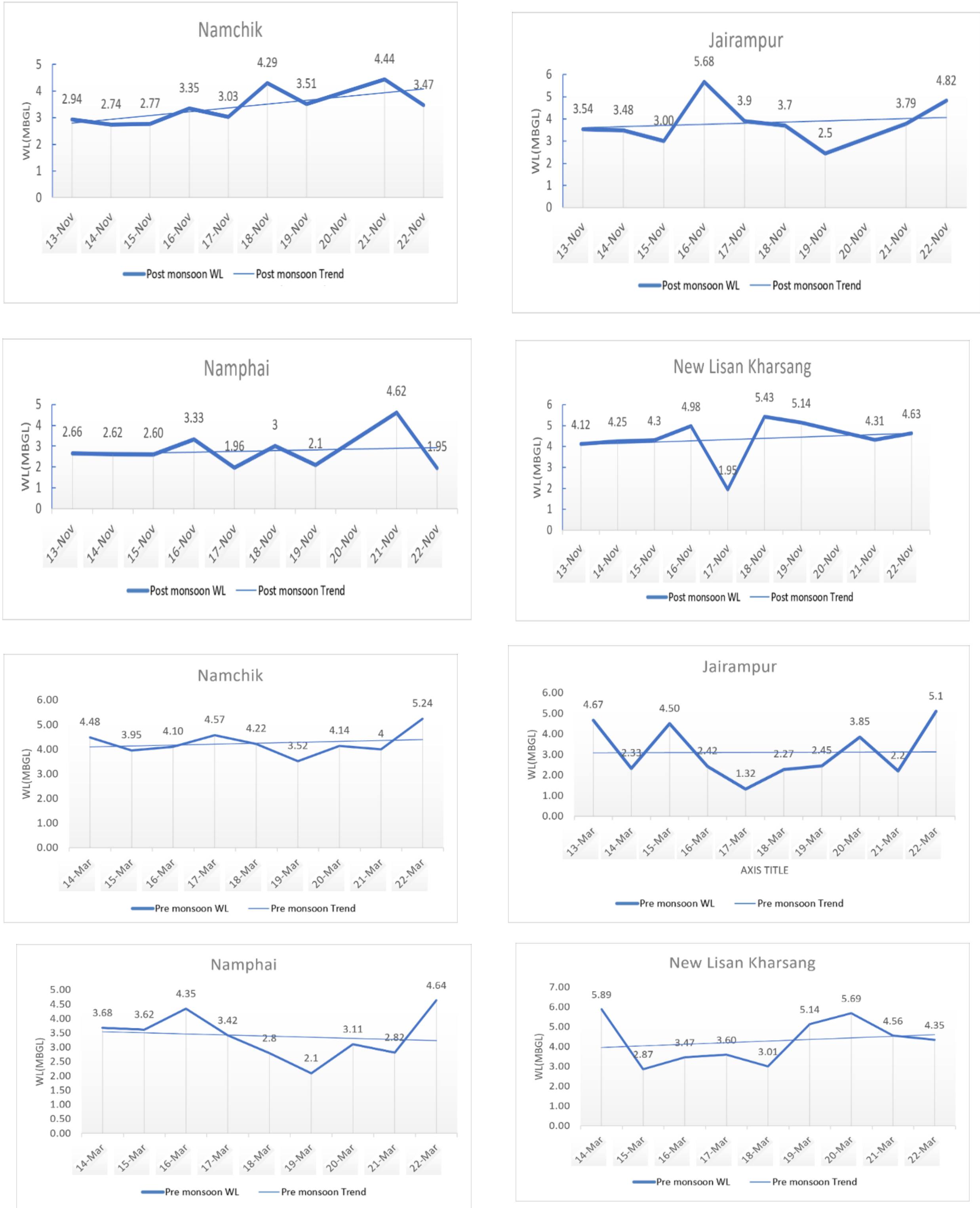


Fig 3.9: Pre & Post monsoon Hydrograph of GWMS wells of study area.

Ground water quality

During AAP 2022-23, 11 nos of Shallow aquifer Groundwater samples were collected from dug well/ hand pump/tube well during post monsoon and 09 nos sample in pre-monsoon for water quality study of Changlang district. Temperature, Ec, pH, and salinity were measured using portable digital quality kit on site. Chemical analysis of ground water samples are carried out by regional chemical laboratory of Central Ground Water Board, North Eastern Region, Guwahati. In the present study the quality of water with respect to major ion, heavy metals, iron, arsenic and uranium, TDS, TH etc. was estimated and various parameter analyzed to evaluate the suitability of ground water in the study area for human consumption and agriculture practices.

Table:3.5. Minimum, Maximum and Mean values of hydro chemical parameters of groundwater samples.

Parameter	**Unit**	**Post Monsoon**				**Pre Monsoon**			
		No of Samples	Average	Max	Min	No of Samples	Average	Max	Min
pH	No unit	11	7.47	8.23	5.94	9	6.93	7.58	6.07
EC	(µs/cm)	11	107.72	163.10	43.67	9	211.37	324.30	97.66
Turbidity	No unit	11	0.10	0.25	0.05	9	0.30	1.35	0.05
TDS	mg/l	11	71.09	107.65	28.82	9	139.51	214.04	64.46
Carbonate	mg/l	11	1.36	6.00	0.00	9	0.00	0.00	0.00
Bicarbonate	mg/l	11	77.14	115.99	30.52	9	98.36	170.94	36.63
TA	mg/l	11	78.51	121.99	30.52	9	98.36	170.94	36.63
Chloride	mg/l	11	12.89	28.36	7.09	9	17.73	28.36	10.64
Sulphate	mg/l	11	6.73	11.72	3.25	9	10.88	17.00	4.44
Nitrate	mg/l	11	5.30	21.14	0.52	9	11.72	33.62	3.17
Flouride	mg/l	11	0.06	0.35	0.00	9	0.25	0.44	0.06
Calcium	mg/l	11	8.92	20.02	4.00	9	15.12	26.02	8.01
Magnesium	mg/l	11	10.59	18.20	3.63	9	11.59	29.12	2.42
TH	mg/l	11	65.91	105.0	30.00	9	85.56	145.00	40.00
Sodium	mg\	11	8.29	19.48	2.09	9	12.82	20.11	7.44
Potasium	mg/l	11	4.57	22.77	1.15	9	5.56	23.47	1.74
Iron	mg/l	11	0.85	6.01	0.07	9	0.12	0.37	0.01
As	mg/l	11	0.56	0.94	0.12	9	BDL	BDL	BDL
SAR	No unit	11	0.51	1.55	0.10	9	0.68	1.31	0.27
PI	%	11	91.79	115.18	65.67	9	84.73	108.35	56.20
RSC	meq/l	11	-0.05	0.50	-0.59	9	-0.10	0.41	-1.09
Na%	%	11	27.34	61.69	6.65	9	31.97	56.78	11.58
KR	No unit	11	0.38	1.41	0.05	9	0.44	0.97	0.11
MH	%	11	64.55	88.23	29.96	9	50.47	82.76	24.95
PS	meq/l	11	0.43	0.91	0.23	9	0.61	0.98	0.35

Drinking Water Quality:

Pre Monsoon and Post monsoon groundwater analysis data has been analyzed and were compared with the Bureau of Indian Standard for drinking water quality (BIS-2012) to evaluate the suitability of groundwater in the study area for human consumption shown in table 3.6.

In Postmonsoon 18.18% of groundwater samples have iron concentration above the permissible limits. In Bordumsa block, highest value has been observed 6.0 mg/l in WRD division. Arsenic concentration in all the samples is within the permissible limit. (Chemical data enclosed in Annexure-I).

In Pre monsoon water sample 100% of groundwater samples have iron concentration within the permissible limits. Arsenic concentration in all the samples are within the permissible limit.

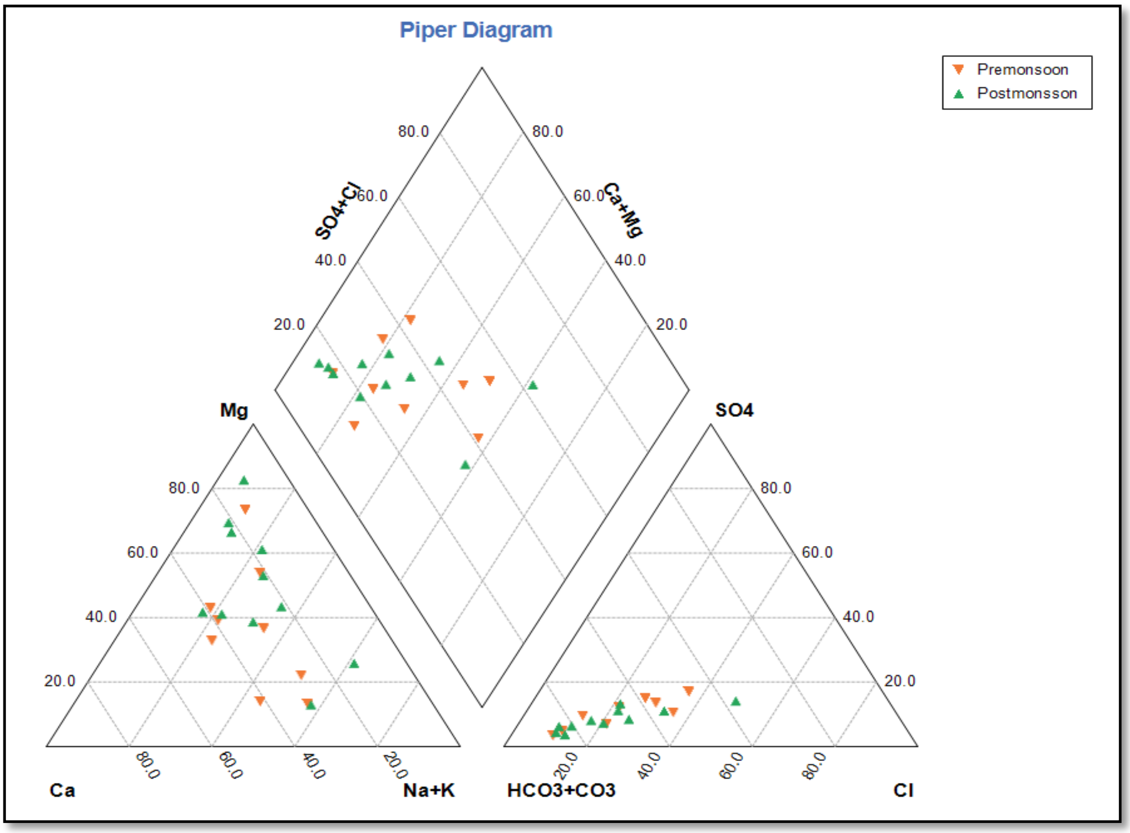


Fig:3.10. Major Hydrochemical facies of Groundwater

Hydrochemical analysis data is plotted in Piper diagram (Fig 3.10). In the present study majority of samples are plotted in Magnesium Bicarbonate field and few samples fall in Na-Cl field.

Table: 3.6. Suitability of groundwater for drinking purposes of study area.

			Post Monsoon		Pre Monsoon	
Parameter	Unit	Permissible Limit BIS (2012)	% of sample under Permissible limits	% of sample exceeding Permissible limits	% of sample under Permissible limits	% of sample exceeding Permissible limits
pH		6.5- 8.5	81.82	18.18	81.82	18.18
TH (as COCO3)	mg/l	600	100	0	100	0
TDS	mg/l	2000	100	0	100	0
Turbidity	NTU	5	100	0	100	0
Calcium	mg/l	200	100	0	100	0
Magnesium	mg/l	100	100	0	100	0
Chloride	mg/l	1000	100	0	100	0
Sulphate	mg/l	400	100	0	100	0
Flouride	mg/l	1.5	100	0	100	0
Nitrate	mg/l	45	100	0	100	0
Iron	mg/l	1	81.82	18.18	100	0

Irrigation Water Quality:

Sodium hazards (Na%), Kelly's Index (KI), Permeability Index (PI), Magnesium Hazards (MAR), Residual Sodium Carbonate (RSC), Sodium Adsorption Ratio (SAR), Potential Salinity (PS) etc parameters has been analysed to evaluate the suitability of ground water in the study area for irrigation. All parameters deciphered the quality of groundwater of study area are Excellent to Good for irrigation purpose and same is Summarized in table 18.

Table: 3.7. Suitability of groundwater (Shallow aquifer) for irrigation in study area.

Based on EC		Post Monsoon	Pre Monsoon
EC (µs/cm)	Water Class	% of samples	
<250	Excellent	100	77.8
250-750	Good	0	22.2
750-2000	Permissible	0	0
2000-3000	Doubtful	0	0
>3000	Unsuitable	0	0
Based on RSC			
RSC meq/l	Water Class	% of samples	
<1.25	Good	100	100
1.25-2.5	Doubtful	0	0
>2.5	Unsuitable	0	0
Based on SAR			
SAR	Water Class	% of samples	
<10	Excellent	100	100
10.0 -18.0	Good	0	0
18.0 - 26	Doubtful	0	0
> 26	Unsuitable	0	0
Based on Na%			
Na%	Water Class	% of samples	
<20	Excellent	36.36	22.2
20-40	Good	45.46	44.4
40-60	Permissible	18.18	33.4
60-80	Doubtful	0	0
>80	Unsuitable	0	0
Based on PI			
PI in %	Water Class	% of Samples	
>75	Class-I, Suitable	81.82	66.6
25-75	Class-II, Good	18.18	33.4
<25	Class-III, unsuitable	0	0
Based on Kelly Index			
KI	Water Class	% of Samples	
<1	Recommended	91	100
>1	Not recommended	9	0
Potential Salinity			
PS in meq/l	Water Class	% of samples	
<3.0	Suitable	100	100
>3.0	Unsuitable	0	0

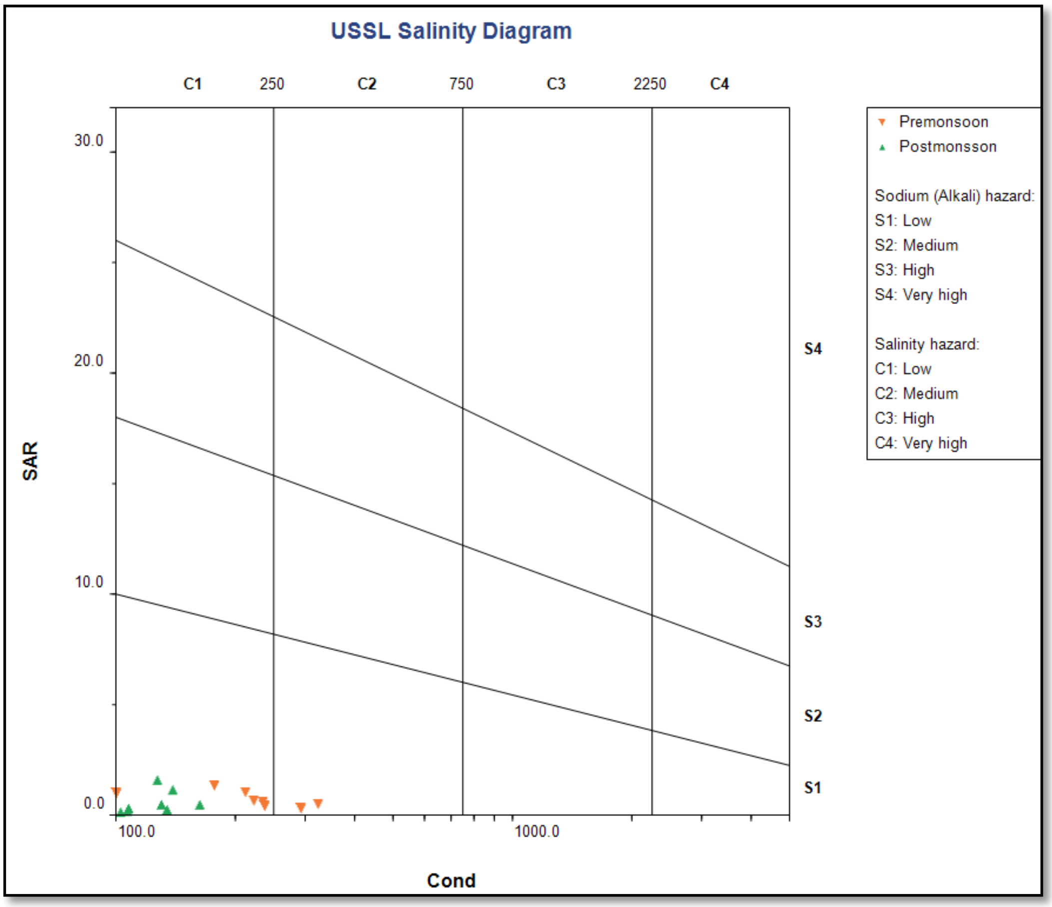


Fig: 3.11. US Salinity diagram showing suitability of groundwater for irrigation based on SAR and EC.

SAR vs EC on the US salinity diagram is shown in Fig 3.11, most of groundwater sample fall in C1S1 and C2S1 indicating low sodium content and low to medium salinity nature of groundwater is good for irrigation purpose.

CHAPTER-4.0

GROUNDWATER RESOURCES

The computation of ground water resources available in the district has been done using GEC 2015 methodology. The dynamic resource estimation is done district wise due to paucity of block-wise data.

Data and assumptions used in the assessment: Following data and assumptions are used in the assessment:

1) Rainfall recharge has been computed by both RIF and WLF methods. To calculate rainfall recharge, both for monsoon and non-monsoon season, RIF factor is considered as 22%. Specific yield has been taken as 12 %.

2) Last ten years rainfall data is considered for groundwater resource calculation.

3) Water level data has been considered for 2020-21. Water level fluctuation based on data of March (Pre monsoon) and November (post monsoon) has been considered since deepest water levels are recorded during the month of March.

4) The population figures were collected from Census, 2011 and projected to 2021.Therefore, domestic extraction is calculated based on per capita water requirement i.e. @60 lpcd for rural and @135 lpcd in urban areas. The dependency on ground water resource for domestic and industrial water supply in rural areas is considered as 76%.

The total replenishable ground water resources available in the study area have been computed using the average water level fluctuations in observation wells and specific yield of aquifers. These have been normalised using normal rainfall data to eliminate variations in recharge due to excess or deficit rainfall. The monsoon recharge arrived at is then compared with the recharge computed using rainfall infiltration method. In cases where the difference between the two is more than 20 percent, the recharge is computed using ad hoc method.

Recharge

Total area of assessment unit 466200 Ha, out of which 53000 Ha considered for recharge worthy area. The aquifers of the study area are recharged through a) infiltration of rainfall b) seepage from the tanks and ponds c) subsurface inflow across the up dip margin. The area experiences south-east monsoon. Monsoon rainfall contributes approximately 76 percent of total rainfall (May, June, July, August, and September). Previous records show that the rainfall occurs almost in every month of a year. The month November to December has the minimum number of rainy days in any year.

The monsoon recharge of recharge worthy area from rainfall is 16679.05 ham while non-monsoon recharge is 7569.09 ham. Recharge from other sources during monsoon is 33274.07 ham and during non-monsoon is 19817.01 ham. Total ground water recharge is 77339.21 ham.

Ground Water Extraction

The ground water extraction of unconsolidated aquifer is created by natural discharge like seepages and draft created by human interference, viz., (a) withdrawals for irrigation and industry and (b) public-supply wells. In the district total natural discharge is 7733.92 ham of the total groundwater recharge. Total irrigation extraction created is 257.15 ham, for industry 0 ham and extraction for domestic uses is 191.10 ham. Total groundwater extraction for all uses is only 448.25 ham. The water trend analysis shows that there is no significant change in the water level for both post-monsoon periods.

Allocation of resources up to 2025

The net ground water resource is allocated for domestic uses are 205.88 ham while 67724.60 ham resources are available for future use.

Stage of Ground Water Extraction

The area has very little irrigation facilities. Similarly, there is no industrial development in the area. Groundwater is mainly utilized for domestic purposes. The stage of groundwater extraction in the district is 0.66%.

Table: 4.1. Groundwater Resources Estimation 2022

PARAMETER	**VALUES**
Total geographical area (Ha)	466200
Recharge worthy area (Ha)	53000
Rainfall Recharge (monsoon) (Ham)	16679.05
Rainfall Recharge (non-monsoon) (Ham)	7569.09
Annual Recharge from Other Sources (monsoon) (Ham)	33274.07
Annual Recharge from Other Sources (non- monsoon) (Ham)	19817.01
Annual G. W. Recharge (Ham)	77339.21
Total Natural discharge (Ham)	7733.92
Annual extractable Ground Water Resource (Ham)	68187.63
Current annual gross G.W. Extraction for domestic use (Ham)	191.10
Current annual gross G.W. Extraction for irrigation (Ham)	257.15
Current annual gross G.W. Extraction for industrial use (Ham)	0.00
Current annual gross G.W. Extraction for All uses (Ham)	448.25
Annual G.W. Allocation for Domestic water supply as on 2025 (Ham)	205.88
Net Annual G.W. availability for future use (Ham)	67724.60
Stage of GW Extraction (in %)	0.66
Quantity Categorisation for Future GW extraction (Safe/Semi-Critical /Critical /Over Exploited)	Safe

CHAPTER-5.0

GROUNDWATER RELATED ISSUES

5.0 Identification of issues:

The main groundwater issues identified in the area are-low stage of groundwater extraction, vulnerable areas under water logging as well as high iron concentration in some pockets.

Low stage of groundwater extraction: Compared to vast dynamic groundwater resource of Changlang district, groundwater extraction for domestic, irrigation and industrial purposes is low. Vast tract of agricultural land remains fallow after harvesting of paddy only due to lack of irrigation facility. The stage of groundwater extraction is only 0.66%.

Area vulnerable to iron pollution: Iron content in ground water, above permissible limit is found in some pockets of the study area. The probable source of Iron in ground water is mostly due to leaching of geological minerals, dissolution of unstable Iron, and chemical transformation within the formation.

Water logged area: There are some parts of the area, which is vulnerable to water logging and having depth to ground water level less than 2.0 mbgl in pre-monsoon. In Innao khamti and Mudoi area of Diyun block where depth to water level is 0.27 and 0.92 respectively. The areas are located at a distance of 2 km from Noadihang River, a tributary of Brahmaputra River which is at similar elevation to the tributary. It is interpreted from water table contour map that the area may receive water from river during lean period thus behaving as influent stream.

CHAPTER-6.0

MANAGEMENT STRATEGIES

6.1 Management of Ground water

The groundwater management involves the optimum utilization of sub-surface water based on geological, hydrological, economic, ecological and legal consideration for the welfare and benefit of the society. The objective of Groundwater management is to utilize the available ground water resources to fulfil human needs and also to boost economy of an area without hampering the interest of future generation. That objective can be achieved by finding out the demand of various sectors and adjusting the demand with available resource.

As per dynamic ground water resources 2021-2022, the annual extractable groundwater of Changlang district is 68187.63ham. The current annual groundwater extraction accounts for 257.15ham and the stage of ground water extraction is only 0.66%. The district is having a balance net ground water availability for future irrigation use in the tune of 67724.6ham. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available, then 40634.76ham of groundwater resources is available in the district for future irrigation uses. Hence, there is ample scope for ground water development for irrigation purpose which will help the district in achieving self-reliance on food grain.

According to Agricultural census, 2015-2016, the district has a net sown area of 34315ha, and grossed cropped area of 45320 ha with a cropping intensity of 132%. The net sown area included field crops as well as horticulture and plantation crops. Cropping intensity is calculated generally from field crops, which are of short duration whereas horticulture (like citrus, banana, pineapple) and plantation crops like spices are long duration crops.

According to Agricultural census, 2015-2016, the land under cultivation during the Kharif season is 10774ha. After growing and harvesting the Kharif crops, the land remains fallow and uncultivated during the Rabi season. The intention of this plan is to utilized and bring this fallow land of 10774ha under assured irrigation during Rabi season which will help to increase the gross cropped area to 21548ha and thereby increase the cropping intensity upto 200%. Since the stage of groundwater extraction is only 0.66%, this area of 10774ha can easily be covered by constructing groundwater-based irrigation projects. In rice fallow, pulses, potato, mustard and rabi vegetables can be grown with the support of irrigation.

To use the groundwater for irrigation, purpose a cropping plan has been designed for the district by using CROPWAT model developed by FAO. Suitable cropping plan was prepared and the cropping pattern, proposed cropping pattern, targeted increase in cropping intensity were shown in tabular form (Table 6.1). Crop wise and month wise precipitation deficit has also been estimated using the same software after giving necessary meteorological, soil data and crop plan inputs and the same has been shown in the Table 6.2. Crop wise and month wise Irrigation Water Requirement (IWR) in ham has been further calculated in Table 6.3.

Table:6.1. Cropping pattern, proposed cropping pattern and intended cropping intensity

Cropping pattern (s)				
Summer Rice- Autumn Rice-Winter Rice	Present cultivated area(**ha**)	Area to be cultivated (%)	Area to be cultivated (**ha**)	Irrigation requirement (**ham**)
Winter Vegetables-Summer Vegetables-Pulses--Potato-Oilseed				
Cultivated Area	**10774**			
	1	2 (= % of 1)	3	4
Rice (main crop)	10774		10774	
Winter Rice	10774	100	10774	1659.627
Potato		25	2693.5	318.06
Pulses		25	2693.5	262.94
Oil Seed		20	2154.8	247.57
Maize (Grain)		10	1077.4	86.84
Winter vegetables		20	2154.8	83.18
Net cultivated area	10774	100		2658.217
Gross cultivated area (Paddy/+Wheat+Pulses)			21548	
Total irrigation requirement				**2658.217**
70% irrigation efficiency				**3797**

Table:6.2. Precipitation deficiency (mm) in Changlang district, Arunachal Pradesh

Precipitation deficit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Winter Rice	0	0	0	0	49.5	98	0	0	0	0	0	0
Winter Rice	0	0	0	0	48.4	98	0	0	0	0	0	0
Winter Rice	0	0	0	0	0	147	0	0	0	5.5	0	0
Winter Rice	0	0	0	0	0.4	146.4	0	0	0	0	0	0
Winter Rice	0	0	0	0	0	48.8	98	0	0	6.5	8.1	0
Winter Rice	0	0	0	0	0	48.8	98	0	0	8.3	23.6	0
Potato	37.1	8.5	0	0	0	0	0	0	0	1.6	28.8	48.2
Potato	39.8	25	5.3	0	0	0	0	0	0	0	13.3	25.5
Pulses	19.3	0	0	0	0	0	0	0	0	1.3	32.9	48.4
Pulses	40	14	0	0	0	0	0	0	0	0	8.4	28.8
Mustard	28	13.6	14	0	2.9	0	0	0	0	1.3	34.3	36.2
Mustard	28	13.6	14	0	0	2.8	0	0	0	0	11	30.1
MAIZE (Grain)	35.3	30.1	7.9	0	0	0	0	0	0	0	1.1	6.2
Small Vegetables	0	0	0	0	0	0	0	0	0	4	48.8	22.7
Small Vegetables	0	1.7	0	0	0	0	0	0	0	0	0	0

Table:6.3. Actual monthly water requirement (Ham) for different crops

Crops	Area %	Jan IWR	Feb IWR	Mar IWR	Apr IWR	May IWR	Jun IWR	Jul IWR	Aug IWR	Sep IWR	Oct IWR	Nov IWR	Dec IWR	Total IWR	Total
Winter Rice	10	0	0	0	0	53.33	105.59	0	0	0	0	0	0	158.92	1659.627
Winter Rice	20	0	0	0	0	104.29	211.17	0	0	0	0	0	0	315.46	
Winter Rice	20	0	0	0	0	0	316.76	0	0	0	11.85	0	0	328.61	
Winter Rice	20	0	0	0	0	0.86	315.46	0	0	0	0	0	0	316.32	
Winter Rice	20	0	0	0	0	0	105.15	211.17	0	0	14.01	17.45	0	347.78	
Winter Rice	10	0	0	0	0	0	52.58	105.59	0	0	8.94	25.43	0	192.53	
Potato	15	59.96	13.74	0	0	0	0	0	0	0	2.59	46.54	77.9	200.73	
Potato	10	42.88	26.94	5.71	0	0	0	0	0	0	0	14.33	27.47	117.33	318.06
Pulses	15	31.19	0	0	0	0	0	0	0	0	2.1	53.17	78.22	164.68	
Pulses	10	43.10	15.08	0	0	0	0	0	0	0	0	9.05	31.03	98.26	262.94
Mustard	10	30.17	14.65	15.08	0	3.12	0	0	0	0	1.4	36.95	39	140.37	
Mustard	10	30.17	14.65	15.08	0	0	3.02	0	0	0	0	11.85	32.43	107.2	247.57
MAIZE (Grain)	10	38.03	32.43	8.51	0	0	0	0	0	0	0	1.19	6.68	86.84	86.84
Small Vegetables	10	0.00	0	0	0	0	0	0	0	0	4.31	52.58	24.46	81.35	
Small Vegetables	10	0.00	1.83	0	0	0	0	0	0	0	0	0	0	1.83	83.18
Total	200							Gross irrigation Requirement with 70% Efficiency							**2658.21696**

Based on available groundwater resources and subsurface condition, the approximate numbers of tube wells that can be constructed in the district is worked out. Groundwater draft is calculated for well discharge of 33.16m³/hr. If the well is allowed to run 8 hours a day for 120 days of a year, then a tube well having a discharge will create a draft of 3.2ham. To meet irrigation demand of 3797ham area, 1192 numbers of shallow tube wells can be constructed to cover an unirrigated area of 21548ha area. It is also considered on the basis of total unirrigated area and 200 m safe distance between each well from all sides. Here, the number of shallow tube wells that needs to be constructed is 2694 in the area of 10774 ha. Therefore, the management plan is proposed following the lowest number of wells which is based on discharge of the wells in the area. The current total extraction of ground water in Changlang district is 257.15ham resulting in a stage of groundwater development of 0.66%. In extracting additional requirement of 3797ham, stage of groundwater development in Changlang will increase from 0.66% to 5.95%.

Irrigation efficiency can be increased by

(i) reducing convenience loss

(ii) improving water application efficiency

Following demand side interventions will increase water use efficiency

1) Use of water efficient irrigation method: Drip and sprinkler irrigation methods are very useful in saving water. Both of them save conveyance losses and improve water application efficiency by applying water near the root-zone of the plant. Drip systems convey water in small quantities through drippers/micro-tubes while sprinklers are pressurized systems where a fountain or spray of water is released by the sprinkler connected by pipes, resulting in foliar irrigation. Drip irrigation can increase crop yield per hectare and also saves water up to 70% than conventional irrigation.

2) Water loss through supply canals can be minimized by proper lining in the canals.

3) Adopting water saving rice irrigation: In this method instead of submerging the paddy field for longer duration, the rice field have to provide water through irrigation only after a certain number of days when the ponded water disappears. This technology is known as alternate wetting and drying (AWD) irrigation. With the optimal management, this technology reduces the amount of water required by about 25% without reduction in yields.

International Rice Research Institute (IRRI) has developed a simple tool to help farmers make decisions on when to irrigate. They found that when field water level recedes to 15 cm below the soil surface, soil water tension in the root zone is always <10 kPa, ensuring good yield. Thus a practical way to implement safe AWD is to monitor the depth of ponded water using a field water tube/ pipe This tube can be made of plastic pipe or bamboo 30 cm long and 15 cm or more in diameter and having perforations on all sides (Fig. 6.1). After transplanting, farmers would keep the field submerged for about 2 weeks to suppress weed growth. The tube is then inserted into the soil by leaving 10 cm above the soil surface. Soil inside the tube is then taken out.

4) Reduce losses of water during leveling: As per Food Agriculture Organization, 200mm of water per hectare is required to level the rice field by traditional method. However, use of laser land leveler help in fine leveling of rice field by eliminating unnecessary depression and elevated contour. It saves 40 to 50% water.A uniformly leveled field allows uniform spreading of irrigated water. It is reported that in Punjab 100% use of laser land leveler in the existing cropping pattern (rice-wheat) can prevent 19cm groundwater draft in entire state (Aggarwal, et. al., 2010).

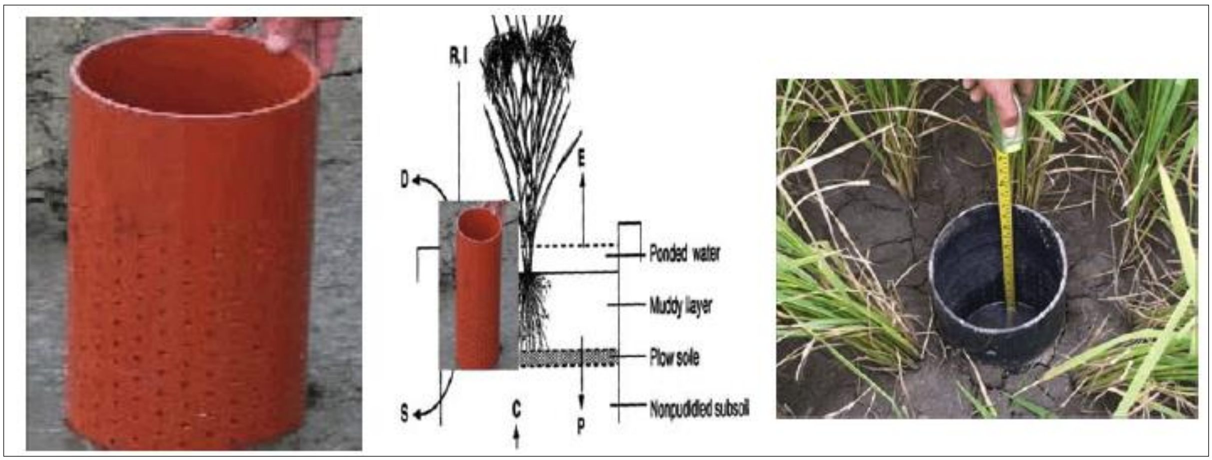


Fig.6. 1: A simple perforated pipe (water tube) installed in the rice field allows farmer to monitor water level beneath the soil surface (Kulkarni, 2011)

Stress aspect future demand: Numerical modelling and aquifer simulation study could not be done due to paucity of various data, it was not possible to test a model under different stress conditions.

Stress on aquifer due to drinking water supply: The population of the study area has been projected based on 2011 census data up to 2025. Based on this projected population drinking water demand of the area is calculated.

Irrigation: The additional withdrawal of water may not adversely affect the ground water regime of the area as major portion of the area is under shallow water table condition.

Following recommendations are suggested

1) Water distribution mechanism should minimize water loss by using lining distribution canals. Locally available materials are to be preferred as these materials are cheap and eco-friendly.

2) Conservation of rain water in the up dip of cultivated field. During rabi season the conserved water can be drained to paddy field through gravity.

Annexure I: Concentration range of chemical constituents in groundwater

Pre/Post monsoon	Location	Lat	Long	Type of sample (EW or DW)	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	CO_3^{-2}	HCO_3^{-1}	TA (as CaCO3)	Cl-	SO_4^{-2}	NO_3^{-1}	F-	Ca^{+2}	Mg^{+2}	TH (as CaCO3)	Na	K	Fe	As
							mg/l															
Pre monsoon	Namchik	27.415	95.972	DW	7.14	324.3	BDL	214.04	BDL	91.57	91.57	28.36	17.00	33.62	0.23	26.02	15.76	130	12.25	8.03	0.01	BDL
	New lisan kharsang	27.427	96.041	DW	6.22	100.5	0.09	66.33	BDL	36.63	36.63	14.18	5.57	16.11	0.22	12.01	2.42	40.0	13.93	1.74	0.03	BDL
	Goju village	27.500	95.908	HP	7.46	293.5	0.10	193.71	BDL	170.94	170.94	14.18	7.32	13.76	0.35	10.01	29.12	145	7.44	2.18	0.37	BDL
	Mudoi gate	27.559	95.963	DW	7.01	237.8	0.07	156.95	BDL	109.89	109.89	21.27	15.52	3.17	0.20	20.02	13.34	105	8.85	3.43	0.18	BDL
	Diyun	27.540	96.103	DW	7.58	235.3	BDL	155.30	BDL	128.20	128.20	14.18	12.37	7.83	0.44	24.02	10.91	105	13.50	2.62	0.03	BDL
	Bordumsa	27.519	95.88	BW	7.43	223.2	0.29	147.31	BDL	152.62	152.62	10.64	4.44	6.19	0.43	12.01	18.20	105	14.59	2.43	0.31	BDL
	Jairampur	27.356	96.014	DW	6.07	177.5	0.18	117.15	BDL	54.94	54.94	24.82	15.46	4.50	0.06	10.01	4.85	45.0	20.11	1.99	0.03	BDL
	Namphai	27.446	96.108	DW	6.87	97.66	0.05	64.46	BDL	61.05	61.05	10.64	4.55	4.76	0.18	8.01	6.06	45.0	8.38	4.18	0.01	BDL
Post monsoon	Innao khamti	27.550	96.016	DW	6.63	212.6	1.35	140.32	BDL	79.36	79.36	21.27	15.73	15.52	0.10	14.01	3.63	50.0	16.34	23.47	0.13	BDL
	Ongman	27.416	95.991	DW	6.23	43.67	0.14	28.822	0	30.524	30.524	10.63	4.637	7.2072	0.01	4.0032	4.852	30	6.85	1.15	0.14	BDL
	Goju	27.500	95.908	DW	7.01	103	0.11	67.98	0	97.678	97.678	7.09	3.709	5.7906	0.01	4.0032	18.20	85	2.09	1.17	0.36	BDL
	Namchik	27.415	95.972	DW	6.54	163.1	0.06	107.64	0	91.573	91.573	17.72	11.72	21.14	0.02	20.016	13.34	105	10.13	6.01	0.12	BDL
	Jairampur	27.356	96.014	DW	5.94	127.5	0.12	84.15	0	36.629	36.629	28.36	10.81	6.0983	0	4.0032	4.852	30	19.48	4.58	0.83	0.116
	Manmao	27.259	95.934	Spring	7.82	71.56	0.08	47.23	0	54.944	54.944	10.63	8.602	1.3731	0.03	8.0064	6.064	45	7.6	2.76	0.29	BDL
	Bordumsa	27.519	95.88	BW	8.23	134.8	0.25	88.968	6	115.99	121.99	10.63	3.715	0.5177	0.07	10.008	18.2	100	4.78	2.25	6.01	0.35
	Namphai	27.446	96.109	DW	7.79	56.27	0.06	37.138	0	42.734	42.734	7.09	3.248	2.191	0	4.0032	6.066	35	4.86	1.41	0.07	BDL
	Miao	27.486	96.177	BW	8.19	130.5	BDL	86.13	6	109.89	115.89	10.63	6.573	3.8109	0.35	8.0064	16.99	90	9.47	3.48	0.11	BDL
	Bijoypur I	27.498	96.011	DW	8.16	107.2	0.05	70.752	0	97.678	97.678	7.09	5.483	2.087	0.09	8.0064	15.77	85	2.97	1.96	0.07	BDL
	Diyun	27.540	96.103	DW	8.08	107.9	BDL	71.214	0	79.363	79.363	10.63	6.525	7.4191	0.05	14.0112	8.488	70	5.04	2.76	0.11	0.94
	Innao khamti	27.550	96.016	DW	8.22	139.4	0.06	92.004	3	91.573	94.573	21.27	8.975	0.7069	0.03	14.0112	3.633	50	17.95	22.77	1.18	0.82